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Pathological and biochemical characteristics of traumatic arthritis in swine reared in confinement

by

Alex Hogg

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
MASTER OF SCIENCE

Major: Veterinary Pathology

Signatures have been redacted for privacy

Iowa State University
Ames, Iowa

1972

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INTRODUCTION

Arthritis is a common problem in commercial swine rearing and in swine used in biomedical research. Many such swine are confined on concrete floors for prolonged periods of time and it is hypothesized that this environment may initiate injuries to the joint that develop into traumatic arthritis.

The economic importance of swine arthritis is apparent from a study of the Federal Meat and Poultry Inspection Statistical Summary for Fiscal 1970. According to this report, arthritis was the second most common cause of antemortem and postmortem condemnation of swine, accounting for 9 to 10% of the total number of carcasses condemned for all causes.

Rheumatoid arthritis of man is of much greater importance than animal arthritis when one considers that each year 320,000 persons in this country are rendered totally unemployable by this disease. Arthritis has been estimated to cost the nation more than one and one-half billion dollars per year (Durman, 1960).

The major etiologic factor in swine arthritis is infection by microorganisms. While infectious swine arthritis has had considerable research effort, little is known concerning the role of trauma in arthritis of swine. There is considerable suspicion that trauma may play an important primary or contributory role in swine arthritis. It seems essential that greater understanding of this aspect of swine

arthritis be obtained because of the magnitude of economic loss resulting from this disease. Swine are also important as a comparative model for the study of joint disease in man.

The pathogenesis of any disease must be understood at the clinical, morphological, and biochemical levels in order to devise procedures to aid in its control. It is intended, by means of this investigation, to increase the present knowledge of traumatic arthritis in swine. To accomplish this, it is necessary to examine articular tissues and body fluids of three classes of swine. Normal swine must be examined as a basis of comparison with diseased or abnormal individuals. Artificially stressed pigs should be examined to determine if the resulting trauma is sufficient to cause discernible changes. Pigs that have become spontaneously arthritic should be examined as a comparison with the other two groups.

REVIEW OF THE LITERATURE

Arthritis

Arthritis is concisely defined as an inflammation of intraarticular structures (Jubb and Kennedy, 1970). The single greatest cause of disability in man is arthritis (Ham, 1969) and it is responsible for a vast amount of suffering and economic loss in animals. It is of historical interest to note that the earliest described evidence of the existence of arthritis was found in the skeleton of a swimming reptile of 100 million years ago, (Hollander, 1966), and many authors indicate that arthritis welded the bones of dinosaurs together. Osgood (1940) observed that arthritis is perhaps the oldest of all diseases known to afflict man. It may also be one of the most publicized as noted by Hamerman and Schubert (1962) in their review of joint diseases (10,000 references in a 13 year period).

The arthritides or diseases of joints can be classified into the following broad areas: 1) developmental disturbances, 2) degenerative diseases (arthropathy), 3) traumatic arthritis, and 4) infectious arthritis (Jubb and Kennedy, 1970).

Traumatic Arthritis

There is a paucity of published reports dealing with the role of trauma in arthritis of animals and man (Durman, 1960). This section

of the LITERATURE REVIEW will deal with clinical and pathologic evidence that trauma does play a role in joint disease of swine, cattle, horses, and man as well as certain experimental approaches to induction of joint damage by means of trauma.

McClellan et al. (1966) attributed the development of arthritis in many experimental swine to the weight of the animals and their continuous maintenance on concrete floors. Swine maintained on asphalt appeared to develop arthritis just as readily as those on concrete.

Osteochondritis dissecans of swine and dogs which is characterized by flaking of juvenile articular cartilage occurs in the shoulder joints of Great Dane dogs and calcium deficient pigs and may be precipitated by trauma (Jubb and Kennedy, 1970). These authors are of the opinion that repeated trauma and nonphysiological stresses may cause a degenerative arthropathy where the primary pathologic change is in the articular cartilage.

In a report on lameness in swine, Rosdail (1965) stated that certain predisposing factors are usually present in cases of traumatic lameness. He implicated environmental factors and leg weaknesses which are accentuated and aggravated by confinement raising.

Fink (1970) noted that the pig that was sound on dirt lots or pastures may no longer be sound on concrete. In a survey conducted in England by Penny et al. (1963), foot lesions were found in 65% of pigs of bacon weight. Lame pigs often improved clinically on soft ground, when given additional bedding, or when housed on "smooth" concrete.

Boars in grass paddocks stayed sound much longer than those on concrete floors. Concussion was mentioned as the cause of the lameness.

Observations by Duncan and Ross (1969) indicate that while arthritis in swine is usually infectious, noninfectious forms do occur. The noninfectious type is an osteoarthritis resulting from trauma.

Neher and Tietz (1959) reported on the incidence of osteoarthritis in bulls confined to stables in artificial insemination studs. They noted that this type of arthritis may exceed 20% in bulls over 9 years of age. Synovitis was usually absent and the pathologic process was characterized by degeneration and erosion of articular cartilage and hypertrophy of bone. Kingrey (1963) stated that osteoarthritis in the bovine has the highest prevalence in bulls being maintained at bull studs. He observed that it occurs in older animals and those that are excessively fat. This author was of the opinion that the condition was caused by sudden strains, bruises, or postural and structural abnormalities which stress the joint.

Van Pelt and Langham (1970) stated that traumatic arthritis in the bovine is usually self-limiting; however, they felt that it can develop into secondary degenerative joint disease, especially if trauma is repeated or severe enough to result in permanent incongruence of the opposing articular cartilages. The changes noted in this work were erosions of articular cartilage and a variation in color of the synovial fluids. Amber coloration of the fluid was attributed to minor intra-articular hemorrhage. They also found the mean leukocyte count to be

457 $\pm$ 136 per mm^3 with a range of 0 to 725.

Van Pelt (1968) described lesions in two cattle with traumatic arthritis. He found that the most characteristic histopathologic changes in the synovial membranes were extensive hemorrhage and edema. There were foci of neutrophils and lymphocytes in the stratum synoviale and early foreign body giant cell formation. The synovial fluid was increased in volume and amber to hemorrhagic. Total leukocyte counts per mm^3 of synovial fluid ranged from 711 to 12,556.

Mackey-Smith (1962) concluded that equine osteoarthritis is directly associated with excessive exertions and the attendant trauma. In a report of studies on the equine, Van Pelt et al. (1970) describe gonitis in ten horses, five of which had a history of trauma. The synovial effusions in these horses ranged in color from pale yellow and clear through amber and opaque to serosanguineous. The mean total leukocyte count per mm^3 was 1223 for arthritic horses and 138 for control horses. There was an increase in total lactate dehydrogenase in the synovial fluid of arthritic horses to 234 units as compared to 56 units for controls. There was a similar response in total protein in synovial fluid, arthritic horses having 3.86% as opposed to 1.41% for controls. The mean albumin: globulin ratio was not reduced in affected horses in comparison to controls.

Neiberle and Cohrs (1966) were of the opinion that the cause of serous arthritis in animals is usually traumatic. Less frequently it may be toxic or allergic and seldom infectious. Serous arthritis is characterized by a serous exudate in the joint cavity; deeper layers of

the joint capsule and the articular cartilage are not involved. Histologic examination of the synovial membrane revealed hyperemia, ecchymotic hemorrhages and a few leukocytes. Chronic exudative (serous) arthritis may develop after infectious or repeated traumatic arthritis. In the chronic form, the synovial membrane is thickened, its villi are elongated, and it often shows almost pelt-like proliferation. It may form a pannus on the articular surface. Hanlon and Estes (1949) observed that osteoarthritis aggravated by trauma in man is a distinct clinical syndrome and is different from traumatic arthritis. Berk (1967) reported on the presence of liquid fat in the knee joint of man after trauma. He stated that fat in the synovial fluid is an indication of intracapsular fracture or a tearing of the synovium.

In a description of traumatic arthritis and allied conditions in man, Abrams (1966) stated that trauma may serve as a precipitating factor in rheumatoid arthritis in a small percentage of cases. He noted that the pathological reaction resulting from trauma varies with the articular part affected and that injury produces a two-fold effect on joints: 1) Primary mechanical damage and 2) Tissue reaction to such trauma. The primary pathologic reaction is synovitis. He further observed that the total cell count of synovial fluid from traumatized joints was 50 to 1,000 cells/mm^3. The protein content was two to three times the normal level, most of the increase being in the albumin fraction.

Wright (1969) discussed the etiology and incidence of osteoarthrosis

in man. Osteoarthrosis is predominantly a disease of the joint itself with the major changes being confined to the articular cartilage. Osteoarthrosis has been found to be prevalent in the knees of colliers, in the elbows of pneumatic drillers, and in various joints of hemophiliacs. Traumatic factors were related by this author to the etiology of the osteoarthrosis in these individuals. Magnuson (1941) was of the opinion that degenerative arthritis in man is the result of often repeated mild trauma.

Experimentally Induced Traumatic Arthritis

Walker et al. (1966) reported on a lesion of the distal ulnar epiphysis of swine. These lesions increased in extent when extra weight was added by strapping saddles that contained lead on their backs. Radiographic examination disclosed rarefaction. Histologic examination revealed zones of hemorrhage and fibrosis that contained variable amounts of necrotic cartilaginous lattice and osteoid tissue. The authors speculated that the lesion is caused by compression of the vascular bed in the epiphysis.

Bauer et al. (1940) injected normal saline into the knee joints of rabbits. This resulted in a rise in the number of polymorphonuclear leukocytes in the synovial fluid. These cells were later replaced by mononuclear phagocytes. The highest cell counts were found in joints showing the greatest hypertrophic or degenerative changes. These changes were confined for the most part to the articular cartilages. The authors

concluded that variations in the total number of cells in synovial fluid of different articulations was an indication of the degree of trauma to which the joint had been subjected.

In other work with rabbits, Frankel et al. (1957) attempted to induce traumatic arthritis by dropping a 200 gram weight from a height of 1 meter on the anterior aspect of the stifle joint. In addition, the same joint was further traumatized by manual rotation of the limb. Findings on postmortem examination consisted of hemorrhage and thickening of the synovial membrane in the acute stage. There was fibrosis of the synovial membrane 14 days following trauma.

Radin and Paul (1971) described an experiment designed to determine the response to impact loading of bovine joints. Metacarpal-phalangeal joints were dissected out after the animals had been slaughtered, cut sagittally, and mounted in an arthrotripsometer which allowed the application of loads of up to 2,000 pounds. The arthrotripsometer was modified by adding a pneumatic loading system which applied a sudden additional load. This dynamic load of 500 pounds was suddenly applied and quickly released. These authors found that when joints were oscillated with a 1,000 pound load, no changes were evident after 200 hours. However, when impacts of 500 pounds were added to a load of 500 pounds, rapid and obvious gross cartilage wear was observed. This wear was manifested by small fissures in the tangential layer of articular cartilage. The cartilage later began to roughen and then the secondary layer became exposed.

Ayers (1965) injected autogenous blood into the radiocarpal and femoro-tibial joints of ponies. Fifteen days later enlargement and hypochromasia of the nuclei of the synovial cells and infiltration of the subvillar tissue by macrophages was observed. Other lesions observed at one and two months postinjection consisted of degenerative changes of the articular cartilage characterized by pyknosis and cytoplasmolysis of the chondrocytes. The matrix of the cartilage was granular and stained intensely eosinophilic. In addition, perivascular infiltration by lymphocytes and plasma cells was observed in the villar and subvillar areas of the synovial membrane.

Gardner (1960) reviewed the literature dealing with the experimental production of arthritis. This author commented that physical agents that are damaging to joints produce forms of arthritis which most frequently resemble degenerative joint disease in man. He was of the opinion that future elucidation of the nature and cause of rheumatoid arthritis in man is unlikely to result from the experimental production of arthritis by physical methods.

Genetic Factors in Arthritis and Lameness

Kowalczyk et al. (1958) described a case of fibrous dysplasia of the bone in swine in which the legs were stiff and the joints and ends of the long bones were thickened. The authors implicated a genetic etiology.

Duthie and Lancaster (1964) described a leg weakness syndrome in

pigs in England which included polyarthritis and epiphyseolysis. The condition usually affected the cubital, femoro-tibial, and tarsal joints of pigs ranging in weight from 5 to 300 pounds. The other limb joints were less commonly involved. The synovial membranes were thickened, reddish, and granular. There was moderate proliferation of synovial villi in many instances. There was marked infiltration of synovial membranes with lymphocytes and plasma cells on histologic sections. It was observed that granulation tissue covered portions of the articular cartilage. The control ration contained 0.6% each of calcium and phosphorus; however, when a mineral mixture containing equal amounts of calcium and phosphorus was added to the control feed to 0.8, 1.0, or 1.2 per cent of each, no significant difference in incidence of the leg weakness could be demonstrated.

In a discussion of lameness in swine, Rosdail (1965) postulated that inherited lameness is due to a lack of resistance. He recommended the selection of breeding animals with a long stride and free, easy gait. The author was of the opinion that animals that walk with short, choppy steps should be culled.

Infectious Arthritis

The major effort in arthritis research in animals has been with infectious agents. To better understand the lesions that may be found in traumatic arthritis, it is necessary to present a short review of lesions encountered in infectious arthritis.

Erysipelas causes chronic arthritis characterized by proliferation of the cells covering the hypertrophied synovial villi (Sikes, 1959). The synovial membrane contains dense aggregates of lymphocytes as well as plasma cells. These features resemble the cellular changes of rheumatoid arthritis in man. Jubb and Kennedy (1970) described the spreading of granulation tissue over the articular cartilage as a frequent lesion in swine erysipelas. Crimmons and Sikes (1965) reported that the synovial fluid in erysipelas infected joints in swine had an average total protein content of 8.14% with a range of 6.6 to 9.9%. These authors also reported an average cell count of 35,930 per mm^3 of synovial fluid with a range of 20,000 to 56,750. Papp and Sikes (1964) made a study of electrophoretic distribution of protein in the serum of swine with a rheumatoid-like arthritis. In test pigs infected with Erysipelothrix rhusiopathiae, they found that affected pigs had significantly higher levels of gamma and beta-2 globulin than controls. There was a decrease in albumin, beta-1 and alpha-2 globulins in sera of affected pigs.

Field et al. (1954) found a high cell count in synovial fluid from piglets with streptococcal arthritis even though only a few streptococci were present. Roberts et al. (1967 and 1968) observed neutrophils and macrophages in synovial fluid from pigs with suppurative arthritis produced by Streptococcus equisimilis. Plasma cells and lymphocytes were the most prominent cells in the synovial membranes at 15 days, 30 days, and six months postinoculation. The synovial membranes also

had areas of fibrinoid formation in the villi at 30 days postinoculation; by six months postinoculation, these areas had become organized nodules of connective tissue. Fibrosis of synovial villi was prominent at 15 days postinoculation. At 30 days postinoculation, the germinal and tangential zones of articular cartilage were hypertrophic and hyperplastic. There was also a broadened zone of hypertrophic cells adjacent to the metaphysis.

Roberts et al. (1963) described the lesions of Mycoplasma hyorhinis arthritis in swine. There were marked hyperemia, edema, and in some cases, fibrin deposits on the synovial membrane. Histologically, there were hyperemia, enlargement of the synovial cells, infiltration of plasma cells, mononuclear macrophages, a few lymphocytes, and occasionally, neutrophils. The predominant cells present in the synovia were neutrophils, appearing at ten days postinoculation. In a more recent study of Mycoplasma hyorhinis arthritis in swine, Ennis et al. (1971) described three chronologically distinctive phases. The first was one of acute, mild synovitis with interstitial edema and inflammatory surface exudate. The second stage exhibited extensive mononuclear cell infiltration of the villi, striking perivascular cuffing, and a concurrent decrease in extra-articular inflammatory change. In the third stage, there were marked synovial hyperplasia, villous hypertrophy, and extensive areas of fibrosis.

McNutt (1959) associated swine arthritis with a pleuropneumonia-like organism. He described the lesions as serous or serosanguineous exudates in the joint cavity; edema and fibrous proliferation of the

periarticular parts. Ross and Duncan (1970) described the microscopic lesions of Mycoplasma hyosynoviae arthritis in swine as villous proliferation of the synovium, increased numbers of synovial lining cells, hyperemia, and perivascular accumulations of lymphoid and plasma cells. Fibroplasia was minimal.

Nutritional Arthritis

Krider and Carroll (1971) listed thirteen nutrients that are associated with lameness and stiffness in swine: calcium, phosphorus, magnesium, manganese, copper, zinc, vitamin A, vitamin D, vitamin E, riboflavin, pantothenic acid, pyridoxine, and choline. The authors pointed out that lameness and stiffness could be due to either deficiency, excess, or imbalance of one or more nutrients.

Whitehair (1958) noted that calcium, phosphorus, and vitamin D deficiencies cause stiffness and lameness in swine. He recommended a calcium level of 0.8% and a calcium-phosphorus ratio of 1:1 to 2:1 in rations for growing swine. He further stated that magnesium deficiency in swine is characterized by weak pasterns, bowed legs, and shifting lameness.

In their study of leg weakness in boars, Walker and Jones (1962) found that when three groups of pigs were fed a ration containing 1.2% calcium and 0.77% phosphorus, only the group fed ad libitum showed severe lesions of leg weakness. Lesions were less severe in groups of pigs on rations restricted in quantity.

Ensminger (1970) described enlargement of knee and hock joints in pigs as a nutritional deficiency or imbalance. He attributed the condition to a lack of calcium, phosphorus, or vitamin D, or to their incorrect ratio.

Brink et al. (1959) observed an arthritic condition in pigs that had been fed 0.2% and 0.4% zinc. There were swollen joints which displayed extensive congestion of synovial membranes on postmortem examination.

Cunha et al. (1968) in their observations on the biotin needs of the pig, described a lameness in pigs and sows which can be reproduced by feeding a diet deficient in biotin. This lameness was caused by cracks in the feet and appeared after five weeks on the purified diet.

Mansson et al. (1971) described a type of arthritis that was thought to be produced by feeding a protein-rich diet that contained 15 to 20% fish meal. The lesions observed were proliferation of the synovial lining cells with villous hypertrophy and highly vascularized granulation tissue containing accumulations of lymphoid cells. These authors were of the opinion that Clostridium perfringens type-A toxins absorbed from the gastrointestinal tract might be the cause of the arthritic lesions.

Synovial Fluid Cytology

Crimmins and Sikes (1965) reported the mean nucleated cell counts for normal swine synovial fluid as 220 cells/mm^3 with a range of 50 to 450. Bollwahn (1967) found minimal to zero cell counts in swine

synovial fluid from arthrosis deformans tarsal joints. Cell counts were too low to make a differential count. Ennis et al. (1971) reported white blood cell counts in synovial fluid from Mycoplasma hyorhinis arthritic swine as averaging 52,000 cells/mm^3 with a range of 17,000 to 78,000.

Perman and Cornelius (1971) noted that an explanation for the apparent differences between nucleated cell counts of synovial fluid taken from various anatomic locations in various species of animals is lacking. They concluded that since the cells involved participate in the inflammatory process, variation between sites may be anticipated even in normal animals.

Synovial Membranes

A typical diarthrosis, or movable joint, consists of opposing articular cartilages, a connecting capsule, and a variable amount of synovial fluid. The synovial membrane lines the fibrous capsule, covers intraarticular ligaments and tendons, and is reflected onto intracapsular bone. It consists of an inner surface layer and a subsynovial layer (Perman and Cornelius, 1971).

In normal pigs, one day to two months of age, Roberts et al. (1969) reported that the lining cell layer of the synovial membrane is one to three cells in thickness.

Clinical Chemistry

Clinical chemistry studies of blood and synovial fluid of normal and diseased swine have been described in the literature. Crimmons and Sikes (1965) reported that normal porcine synovial fluid contains 3.9% total protein. In contrast, Bollwahn (1967) reported that normal porcine synovial fluid contains only 1.62% protein.

Barthel (1970) examined 50 swine weighing 85 to 100 kg. and found a mean of 1.3 grams of protein per 100 ml. of synovial fluid. In 14 to 28 kg. normal pigs, the mean was 0.5 grams per 100 ml. When similar pigs were infected with Mycoplasma hyorhinis, the total protein content was 2.6 grams per 100 ml.

Clinical enzymatic studies on normal and diseased swine have also been presented in the literature. Lactic dehydrogenase (LDH) catalyzes the oxidative conversion of lactate to pyruvate. Swine tissues, as well as most other mammalian tissues, contain LDH which may be separated into five distinct forms by electrophoresis. These different forms are called isoenzymes (Zimmerman and Henry, 1969).

Barthel et al. (1971) reported on blood and synovial fluid levels of lactic dehydrogenase in control and Mycoplasma hyorhinis infected swine. He also presented the mean distribution (%) of LDH isoenzymes in these fluids.

Goodfriend et al. (1965) discussed the effect of anoxia on the synthesis of LDH. They postulated that low oxygen tensions may result

in increased synthesis of messenger RNA for M subunits.

Greenberg (1967) and Cantarow and Schepartz (1967) reviewed the chemistry of mammalian LDH isoenzymes and their distribution in the various tissues. Briefly, M_4 (LDH_5), the isoenzyme fraction with the slowest mobility (cathodic), has a higher concentration in tissues that are highly dependent on glycolysis such as skeletal muscle. Meanwhile, H_4 (LDH_1), the fraction with the greatest mobility (anodic), predominates in tissues with purely aerobic or respiratory metabolism such as the heart. Zimmerman and Henry (1969) pointed out that the large number of conditions in which elevated LDH levels are seen reduce the usefulness of its measurement as a diagnostic aid. Prasse (1969) stated that isoenzyme patterns enhance the diagnostic ability of LDH studies.

Tushan et al. (1969) found that articular cartilage of several species has a high concentration of LDH_4 and LDH_5. In their studies, these two fractions accounted for approximately 70% of the total activity of LDH in this tissue.

MATERIALS AND METHODS

Experimental Swine

Thirty-three pigs from eight litters of Hampshires and two litters of Yorkshires were utilized in these studies. The sex distribution was 22 males and 11 females.

Ten clinically normal Hampshire swine from four different litters were obtained from the Veterinary Medical Research Institute herd at approximately five weeks of age and reared in isolation. These pigs had been farrowed normally and allowed to nurse their dams. The herd of origin was known to be infected with Mycoplasma hyosynoviae, an arthritis producing microorganism, but the practice of weaning at four to five weeks of age and rearing in isolation has been successfully used to derive Mycoplasma hyosynoviae-free pigs. The reason for the low incidence of infection in pigs up to four or five weeks of age is unknown. As an added precaution to establish that the pigs were free of infection with Mycoplasma hyosynoviae, pharyngeal secretions were cultured and found to be negative on two different occasions after the pigs were placed in isolation units.

The remaining 23 pigs used in the experiment were all derived by cesarean section and reared deprived of colostrum on a commercial sow milk replacer (SPF-Lac[1]). These cesarean-derived, colostrum-deprived pigs are designated as CDCD. Their origin was as follows: 11 Hampshire pigs were from two sows obtained from a local swine producer and four

[1]Borden Chemical Co., Smith-Douglass Div., Norfolk, Virginia.

Hampshire pigs from one sow and eight Yorkshire pigs from two sows were from the Veterinary Medical Research Institute herd.

Commercial 18% protein pig starter ration (Flav-r-ized Pig Nuggets[1]) containing 100 gm/ton of chlortetracycline, 0.011% sulfa-methazine and 50 gms/ton of penicillin and 18% protein starter-grower ration (Pig Gold[1]) containing 40 gms/ton of Tylosin was fed to CDCD pigs until they were about eight weeks of age. Non-CDCD pigs were fed 18% protein starter and 16% grower rations which were devoid of antibiotics. The antibiotic-free grower ration contained by analysis[2] 0.8% calcum and 0.7% phosphorus. This ration was fed ad libitum to both non-CDCD and CDCD pigs from about eight weeks of age until postmortem examination. Postmortem examinations were carried out at ages varying from 128 days to 384 days and weights ranging from 117 to 421 pounds. The experimental swine were housed in isolation units with smooth concrete floors for the duration of the test period. These units provided from ten to 25 square feet of floor space per animal, varying with the size of the pigs. Non-CDCD and CDCD pigs were always housed in separate isolation units to preclude exposure of the CDCD pigs to unknown pathogenic agents which might have been carried by the non-CDCD pigs.

Study Groups

Each of the 33 test pigs was assigned to one of five groups. Eighteen Hampshire pigs were randomly assigned to one of three groups

[1]Kent Feeds, Inc., Muscatine, Iowa.

[2]Iowa Veterinary Diagnostic Laboratory, Iowa State University, Ames, Iowa.

of six pigs each. One group was designated as controls with no treatment. The second and third groups were designated to be stressed on a shaking device prior to postmortem examination. Sex and origin were taken into account where feasible in making these randomized groupings.

The eight Yorkshire pigs were assigned to a fourth group to serve as controls for breed comparison. The fifth group was composed of seven Hampshire pigs that had become lame before the first three groups had been selected. Five of the pigs in group 5 were euthanized and examined a few days to two weeks after lameness was first apparent. Two pigs were retained until the lameness had progressed to the chronic stage or about four months after locomotory difficulty was first observed. The origin, breed, sex, identification numbers, and weights of pigs assigned to the five groups are shown in Table 1.

Postmortem examinations were made on the pigs in groups 1, 2, 3, and 4 at weights ranging from 117 to 282 pounds. There was a wider range of weights in the spontaneously lame pigs of group 5, their weights ranging from 113 to 421 pounds.

In order to obtain a maximum return of information, each of the 33 test pigs was further assigned to four groups according to history of severity of lameness. Pigs that had never shown clinical signs of lameness during the course of the experiment were placed in the first group. Pigs with a history of mild, moderate, or severe lameness were assigned to a second, third, or fourth group, respectively. The origin,

Table 1. Origin, breed, sex, identification number, and weight at postmortem of pigs assigned to five study groups

Group[a]	Origin and Weight at Postmortem					
	CDCD[b] producer[c]	Weight (lbs.)	CDCD VMRI[d]	Weight (lbs.)	Non-CDCD VMRI	Weight (lbs.)
1	H19-2B[e]	184			H65-30B	185
	H20-2B	181			H65-40G	198
	H20-6B	215				
	H20-7G	248				
2	H19-5G	165			H65-31B	222
	H20-5B	155			H65-33G	152
					H65-50B	212
					H65-53B	196
3	H19-1B	196			H65-62B	210
	H19-3B	170				
	H20-1B	248				
	H20-3B	282				
	H20-8G	117				
4			Y13-40G	236		
			Y13-60B	231		
			Y13-70B	248		
			Y13-80G	170		
			Y16-01G	202		
			Y16-02G	205		
			Y16-03G	191		
			Y16-04B	184		
5			H09-06B	421	H65-31G	175
			H09-07G	399	H65-33B	141
			H12-10B	142	H65-34B	113
			H12-20B	183		

[a]Group 1. Hampshire controls, no treatment.
Group 2. Hampshires, shaken four days pre-examination.
Group 3. Hampshires, shaken 11 days pre-examination.
Group 4. Yorkshire controls.
Group 5. Hampshires which developed spontaneous lameness.

[b]CDCD = Cesarean-derived, colostrum-deprived.

[c]Producer = Local swine producer.

[d]VMRI = Veterinary Medical Research Institute.

[e]H = Hampshire. Y = Yorkshire. B = Male. G = Female.

breed, sex, identification number, and weight at necropsy of pigs assigned to these four groups are shown in Table 2.

Methods of Inducing Joint Trauma

It was hypothesized that the diarthrodial joints of the limbs of pigs were subjected to constant, mild trauma when confined on concrete floors. Other causes of stress on joints include hauling in trucks or supporting the extra weight of heavy muscling or of rapid growth. In order to intensify and accelerate joint trauma, a shaker was constructed (Figures 1-8). A one-third horsepower, 115 volt, electric motor (1725 RPM) was used to power the shaker. A series of pulleys and V-belts were arranged so that the floor delivered 100 vertical shakes per minute. The lift on each cycle was 1.3 cm. A 46 inch x 18 inch wooden crate was fastened to the top of the shaker.

All 12 of the pigs in groups 2 and 3 were subjected to a single period of shaking when their ages ranged from 149 to 195 days. One pig each from groups 2 and 3 was shaken for a 15 minute period on a given day. Postmortem examination was performed on the group 2 pig four days later and on the group 3 pig 11 days after shaking. This procedure of shaking two pigs in one day was continued until all six pigs in each of groups 2 and 3 had been shaken and postmortem examination completed. The time of postmortem examination of control pigs was generally concurrent with the postmortem examination time of the pigs of groups 2 and 3 but not on the same days.

Table 2. Origin, breed, sex, identification number, and weight at postmortem of pigs grouped by history of lameness

Animal group	Origin and Weight at Postmortem					
	CDCD[a] producer[b]	Weight (lbs.)	CDCD VMRI[c]	Weight (lbs.)	Non-CDCD VMRI	Weight (lbs.)
Never lame	H19-2B[d]	184	Y13-40G	236	H65-30B	185
	H20-2B	181	Y13-80G	170	H65-40G	198
	H20-6B	215	Y16-01G	202		
	H20-7G	248	Y16-02G	205		
			Y16-03G	191		
			Y16-04B	184		
Mild lameness	H19-1B	196	Y13-70B	248	H65-50B	212
	H19-3B	170				
	H19-5G	165				
	H20-1B	248				
	H20-3B	282				
	H20-5B	155				
	H20-8G	117				
Moderate lameness			H12-10B	142	H65-31B	222
			H12-20B	183	H65-31G	175
			Y13-60B	231	H65-33G	152
Severe lameness			H09-06B	421		
			H09-07G	399		
					H65-33B	141
					H65-34B	113
					H65-53B	196
					H65-62B	210

[a]CDCD = Cesarean-derived, colostrum-deprived.

[b]Producer = Local swine producer.

[c]VMRI = Veterinary Medical Research Institute.

[d]H = Hampshire. Y = Yorkshire. B = Male. G = Female.

Figure 1. End view of pig shaker with crate in position for shaking pig

Figure 2. End view of pig shaker with crate removed

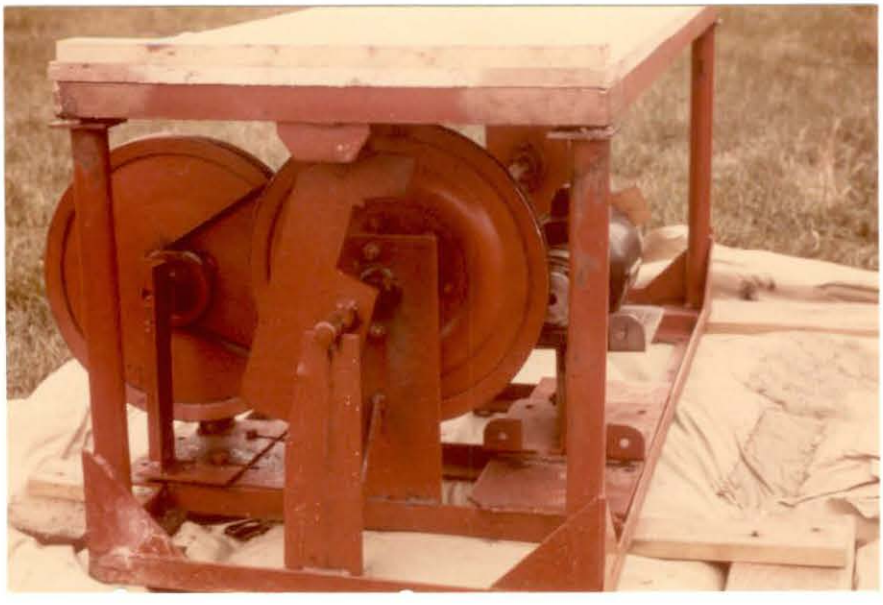


Figure 3. Side view of pig shaker. Note clamps used to fasten crate to platform of shaker

Figure 4. Overall view of shaking mechanism with platform removed

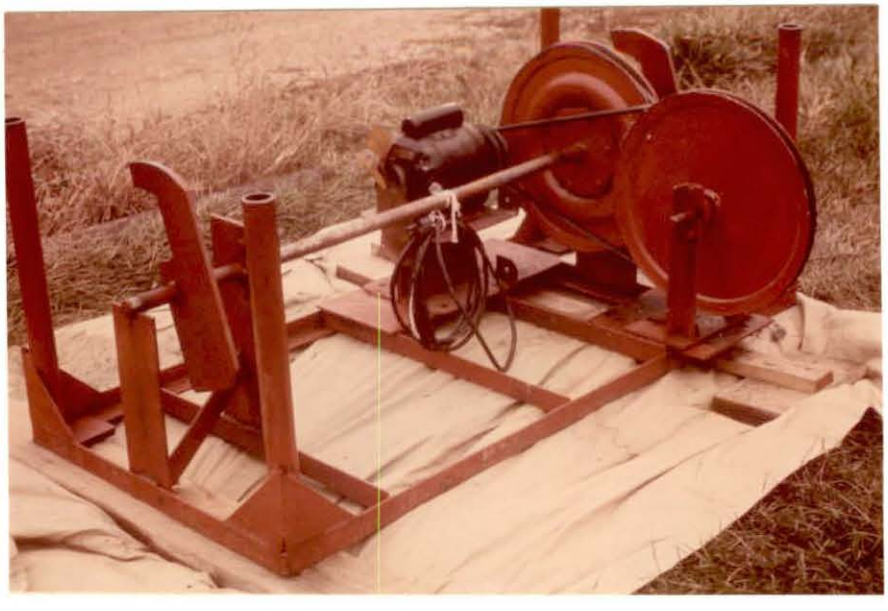
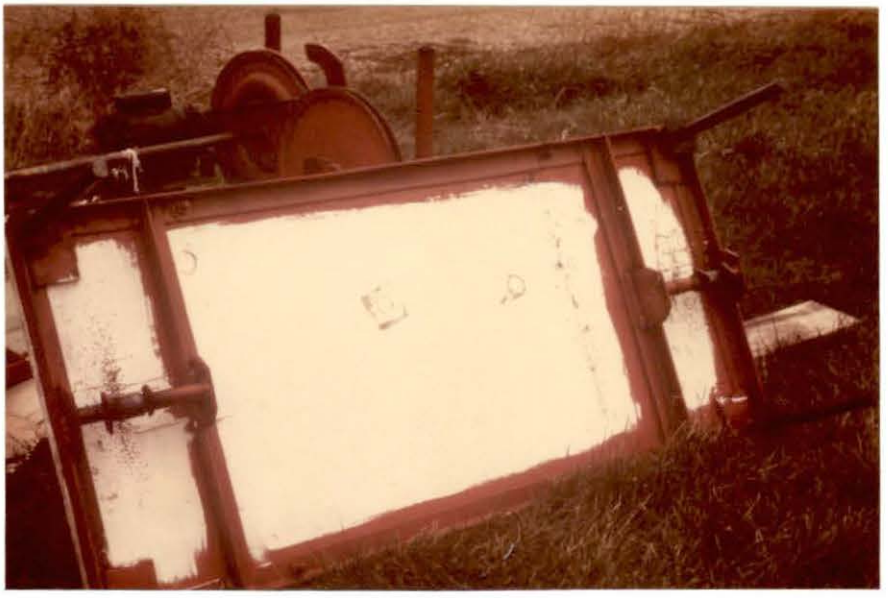


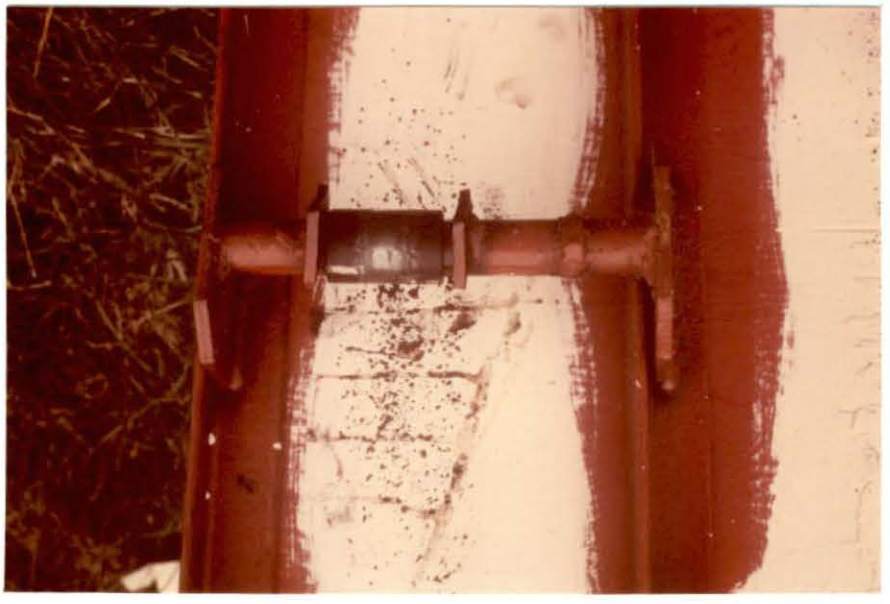
Figure 5. View of pig shaker mechanism with details of v-belt and pulley arrangement

Figure 6. Pig shaker mechanism. Note cam that lifts platform

Figure 7. View of underside of platform of pig shaker. The legs fit into the upright pipes of the shaking mechanism

Figure 8. View of underside of platform of pig shaker. Note roller which cam contacts at each lift of shaker





Euthanasia

Each pig was weighed and brought to a state of surgical anesthesia by injection of pentabarbital sodium solution intravenously via the marginal ear vein. Anesthesia was selected over electrocution to avoid traumatic injury to the joints which sometimes occurs during the tetanic contractions induced by the latter. Exsanguination was effected by severance of the axillary vasculature.

Specimen Collection

Approximately 50 ml of blood was collected at the time of exsanguination in a plastic tube and allowed to clot. The serum was harvested by centrifugation and stored frozen at -70° C.

All four limbs were removed from the carcass and the skin reflected over each of the eight joints to be sampled. After searing the subcutaneous fascia with a hot spatula, as much synovial fluid as possible was aseptically aspirated from each joint by the use of sterile disposable plastic syringes and needles. The joints sampled were the right and left scapulohumeral, cubital, femorotibial and tibiotarsal articulations. That portion of the fluid to be used for clinical chemistry was placed in tubes containing two drops of an EDTA anticoagulant (Sequester-Sol[1]) and inverted several times. The synovial fluid was examined grossly and its description and amount were recorded. A small amount (0.1 to

[1]Cambridge Chem. Products, Inc., Detroit, Michigan.

1.2 ml) of synovial fluid was retained in the plastic syringe for microbiologic culture examination. If no fluid could be aspirated, the articulation was opened and samples for microbiologic culture examination were aseptically collected with sterile cotton tipped applicators.

Secretions from the surface of the tonsil, nasal and nasopharyngeal mucosae, and tissue fluids from the incised tonsil were collected for mycoplasma culture examination with sterile cotton tipped applicators. Two strips of tonsil approximately 0.5 cm by 1.5 cm were excised from each pig and frozen for subsequent culture examination for Erysipelothrix rhusiopathiae.

The designated joints were opened and examined for gross pathologic change. Two sections of synovial membrane were collected from each of the eight joints of each pig and fixed in buffered 10% formalin solution. Sections of cartilage and the underlying bone were collected from two locations in the right and left femorotibial articulations (stifle joints) of each pig. The first sample was taken from the nonweight bearing surface of the femoral trochlea and the second from the weight bearing surface of the femoral condyles.

Additional tissues collected for histologic study were the right and left subiliac and popliteal lymph nodes. Sections of liver, spleen, lung, and kidney were also taken. All tissues were immediately fixed in buffered 10% formalin solution.

Microbiological Methods

The synovial fluid samples were streaked on 5% horse-blood agar plates. A micrococcus "nurse" culture, for support of possible Hemophilus spp. was streaked across each plate at right angles to the initial streaking.

Mycoplasma broth medium containing 85% v/v fresh beef heart infusion and 15% v/v heated turkey serum was inoculated with synovial fluid, mucous membrane secretions, and tissue specimens (Ross and Karmon, 1970). Penicillin (1000 u/ml) and thallium acetate (1:4000) were added as bacterial inhibitors. In addition, 2, 3, 5-triphenyl 2H tetrazolium chloride was added as a growth indicator. Blood agar plates were incubated in aerobic and anaerobic (GasPak[1]) atmospheres at 37° C. Plates were examined after two and five days incubation for evidence of bacterial growth. Mycoplasma broth was incubated at 37° C with the screw-caps tightly fastened and examined daily for visible evidence of turbidity or growth indicator change. After three days, each broth culture was passaged to a second tube which was incubated and observed for seven days. Bacteria isolated were identified by standard procedures and mycoplasmas were identified by direct "epi" immunofluorescence of colonies (Del Giudice et al., 1967).

Pieces of tonsil approximately 0.5 cm by 0.5 cm were ground in broth with motor driven, glass tissue homogenizers (Tri-R[2]) and poured

[1]BBL, Division of BioQuest, Cockeysville, Maryland.

[2]Tri-R Instruments, Inc., Rockville Centre, New York.

into 100 ml of a selective broth medium designed for isolation of Erysipelothrix rhusiopathiae from contaminated material (Wood, 1965). Broth cultures were incubated at 37° C and subcultured after 24, 48, and 72 hours on to modified Packer's medium. Packer's medium plates were incubated at 37° C in a high humidity incubator[1] and observed daily for five days for evidence of colonies. Bacteria isolated on this medium were identified according to standard methods.

Synovial Fluid Analysis

Synovial fluid samples collected as described with EDTA were evaluated for total lactic dehydrogenase (LDH), LDH isoenzyme distribution, total protein, and protein fraction distribution. In some cases insufficient volume of synovial fluid was obtained. Where necessary and feasible, fluids from contralateral joints were pooled to provide enough for analysis.

Total lactic dehydrogenase (LDH)

All LDH determinations were performed within four to six hours of sample collection. Samples of synovial fluid were analyzed for total LDH activity via the colorimetric method of Cabaud and Wroblewski (1958). Following a 30 minute color development period, the individual samples were placed in 12 mm cuvettes and per cent transmission was read at 540 nm in a spectrophotometer (Coleman Junior, Model 6D[2]). The

[1]National Appliance Co., Portland, Oregon.

[2]Coleman Instruments, Inc., Maywood, Illinois.

per cent transmittance, using water as a reference, was recorded. Enzyme activity in Wroblewski units per ml was obtained for each sample from a previously constructed per cent transmission calibration curve.

LDH isoenzyme distribution

Electrophoretic separation of the LDH isoenzymes was accomplished in the manner described by Wright et al., (1966). The synovial fluid was digested with hyaluronidase to facilitate electrophoretic separation, applied directly to cellulose acetate membranes, electrophoresed, reacted, and scanned densitometrically.

Phosphate buffer (pH 7.5) 0.03M for use in the electrophoresis cell and as a diluent contained the following:

Dibasic sodium phosphate	11.8 gm
Monobasic potassium phosphate	3.8 gm
Sucrose	4.5 gm
Distilled water	3000 ml.

The ingredients were mixed and the pH was checked with a pH meter (Beckman, Zeromatic II[1]).

Hyaluronidase solution was prepared as follows:

Testicular hyaluronidase (Sigma[2])	3.0 mg
Phosphate buffer (pH 7.5)	0.9 ml.

The ingredients were thoroughly mixed until the enzyme was completely dissolved (Barthel et al., 1971).

[1]Beckman Instruments, Inc., Fullerton, California.

[2]Sigma Chemical Co., St. Louis, Missouri.

Synovial fluid digestion was accomplished by mixing the enzyme preparation with the synovial fluid in the following proportions:

Hyaluronidase solution	0.1 ml
Synovial fluid	0.3 ml.

The synovial fluid was digested at 37° C for two hours and then applied to the electrophoresis membrane.

A single drop of each digested sample was placed on a thin sheet of paraffin (Parafilm "M"[1]). Uniform volumes of sample were applied to pre-buffered and cell-positioned cellulose acetate membranes with the aid of a 0.25 L applicator (Beckman Sample Applicator[2]). Six applications of synovial fluid digestate were necessary for adequate isoenzyme resolution.

The electrophoresis cell (Beckman Microzone Cell[2]) containing the 0.03M phosphate buffer (pH 7.5) was set in an ice bath to prevent heat denaturation of the enzyme during the prolonged run. The cell was connected to the power supply (Beckman, Duostat[2]) and electrophoretic separation was carried out at 140 volts and five to ten milliamperes for one hour. After electrophoresis, the membrane was removed and incubated in the dark at 37° C for 40 minutes in contact with an agarose-reactant mixture as described by Wright et al., (1966) and modified by Prasse (1969). Upon completion of the incubation period, the membrane

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[1]Marathon Products Div., American Can Co., Neenah, Wisconsin.

[2]Beckman Instruments, Inc., Fullerton, California.

was washed in a stream of distilled water, dried between blotters, and stored in a plastic holder. The dried membrane was scanned densitometrically using a 530 nm filter (Beckman Microzone Densitometer, Model R-110[1]) without clearing and per cent transmission was graphically recorded. The relative percentage of each of the five isoenzymes was determined by the use of a compensating polar planimeter.

Total protein

Total protein content of serum and synovial fluid was determined by the Lowry method (Lowry et al., 1951). Dilutions of 1:70 for synovial fluid and 1:300 for serum were used. Following a 45 minute color development period the optical density was determined with a spectrophotometer (Coleman Junior, Model 6D[2]) using a 660 nm filter. Total protein was calculated from a standard curve.

Protein fraction distribution

Serum samples were applied directly to the electrophoresis membrane but again it was necessary to first digest synovial fluid with hyaluronidase to allow adequate electrophoretic migration. In this instance, barbital buffer (Beckman Buffer B-2[1]) at a pH of 8.6 was used as an enzyme diluent and for filling the electrophoresis cell.

Samples were applied to the electrophoretic membrane as with LDH

[1]Beckman Instruments, Inc., Fullerton, California.

[2]Coleman Instruments, Inc., Maywood, Illinois.

except that only one application of serum was necessary for adequate resolution. Two applications of synovial fluid digestate were required for satisfactory resolution.

The electrophoresis cell containing barbital buffer at pH 8.6 was connected to the power supply and electrophoretic separation was carried out at 250 volts and three to nine milliamperes for 50 minutes. Following electrophoresis, the membrane was treated with Ponceau-S fixative-dye solution and decolorized in 5% acetic acid solution (Beckman, 1965). The membrane was then rinsed well with distilled water and dried overnight between blotters. The dried, uncleared, membrane was placed in a clear plastic holder and scanned on a densitometer (Beckman Microzone Densitometer, Model R-110[1]) using a 606 nm filter and per cent transmission was graphically recorded. This permitted the relative percentage of each of the protein fractions to be determined by means of integration marks.

Synovial Fluid Cytology

Synovial fluid was diluted for total cell counts by mixing 0.1 ml of the well-stirred fluid (Super-Mixer[2]) with 0.1 ml of a 0.1% methylene blue in 0.85% saline solution (Krieg, 1969, p.1170). This mixture of synovial fluid and stain was used to fill the counting chamber of a standard hemacytometer (Spencer Bright-Line[3]). Cell counts of synovial

[1]Beckman Instruments, Inc., Fullerton, California.

[2]Matheson Scientific Co., Chicago, Illinois.

[3]American Optical Co., Buffalo, New York.

fluid were made in the usual manner, taking into account the 1:1 dilution used instead of the usual 1:10 dilution for blood, and results recorded.

Histologic Methods

Tissue samples for histologic study were removed from formalin solution, processed by standard paraffin techniques, cut at five microns, and stained with Harris hematoxylin and eosin-Y by the procedure described in the manual of Histologic and Special Staining Techniques (Armed Forces Institute of Pathology, 1968). Bone and cartilage sections were decalcified by submerging them in a 10% solution of disodium EDTA for 30 days.

Numerical Evaluation of Gross and Microscopic Articular Lesions

Numerical values were assigned subjectively to the gross and microscopic lesions observed in each of eight joints of each pig. This was necessary in order to adapt these observations for digital computer programming and concurrent analysis with data derived from other procedures.

Derivation of gross lesion scores

Joints that appeared grossly normal were assigned a value of 1. Joints that exhibited one or more lesions that included hyperemia, edema,

villous hypertrophy, yellowish or brownish discoloration, or fibrosis, were assigned values of 2, 3, or 4. A value of 2 indicated a mild lesion, 3 a moderate, and 4 a severe lesion.

Gross appearance was used as the criterion for scoring changes in the aspirated synovial fluid. Clear to slightly yellow fluid with no turbidity was considered normal and was assigned a value of 1. Synovial fluid was considered abnormal if it was turbid, brownish yellow, serosanguineous, or had a combination of these characteristics. Values of 2, 3, or 4 were assigned according to the severity of these changes.

Gross lesion and appearance of synovial fluid values were added together for each of the joints studied. This method of evaluation resulted in a scale of 2 to 8 with 2 representing a normal joint and 8 a joint with the most severe changes.

Derivation of microscopic lesion scores

The two stained histologic tissue sections from the synovial membrane of each joint under study were examined by light microscopy. The following six lesions were observed in a portion of the 264 joints examined and were designated as lesions A, B, or C as shown below:

Lesion - A

1). Lining cell hyperplasia

2). Villous hypertrophy

Lesion - B

3). Vascular proliferation

4). Fibrosis

Lesion - C

5). Foci of lymphocytes and plasma cells

6). Perivascular infiltration of lymphocytes and plasma cells.

Both sections of synovial membrane from each joint were examined for each of the six lesions. If a joint appeared grossly normal, a rating of 1 was assigned to indicate normal. If a lesion was evident, it was assigned a numerical rating of 2, 3, or 4 according to severity, 2 being least and 4 the most severe. These ratings were recorded on specially prepared forms and totals of lesions A, B, and C for each joint and each pig were calculated. The completed form for a typical pig is reproduced as Figure 9.

Carcass Data

Backfat measurements were made on the midline at three places--opposite the first rib, the last rib and the last lumbar vertebra. These measurements were made in tenths of inches and recorded. Hams were cut out, using the method commonly employed in meat packing plants, weighed and the weight recorded. The loin eye area (cross-section of the longissimus dorsi muscle) between the tenth and eleventh ribs was traced on acetate paper. The area was determined by use of a plastic grid (AS-235, Sept., 1967[1]) and the data recorded in square inches. The carcass data was adjusted to a standard weight of 220 pounds for

[1]Cooperative Extension Service, Iowa State University, Ames, Iowa.

PIG #H65-33B

JOINT	Lining Cells	Villous Hypertrophy	Vascular Prolif.	Fibrosis	Foci-Lym. Pl. Cells	Perivas-Lym. Pl. Cells	Total - Lesion A	Total - Lesion B	Total - Lesion C
Rt. Sh-L	2	2	3	2	1	1			
Rt. Sh-S	3	2	2	2	1	1	9	9	4
Rt. Cub-L	2	3	2	2	1	1			
Rt. Cub-S	3	1	2	2	1	1	9	8	4
Rt. Stif-L	3	3	2	2	1	2			
Rt. Stif-S	3	3	2	2	1	1	12	8	5
Rt. Hock-L	3	2	2	2	1	1			
Rt. Hock-S	3	2	2	2	1	1	10	8	4
Lt. Sh-L	3	3	2	2	1	1			
Lt. Sh-S	2	2	2	2	1	1	10	8	4
Lt. Cub-L	1	1	2	2	1	1			
Lt. Cub-S	2	3	2	2	1	1	7	8	4
Lt. Stif-L	3	2	1	2	1	1			
Lt. Stif-S	3	3	2	2	1	1	11	7	4
Lt. Hock-L	3	1	1	2	1	1			
Lt. Hock-S	3	1	1	2	1	1	8	6	4
						Totals	76	62	33

Figure 9. Completed form used to record microscopic lesion scores

each pig. An index of the degree of muscling of each pig was then determined from the adjusted data by the following described four procedures (AS-289, October, 1968[1]).

Backfat adjustment

The observed weight of the pig was multiplied by 0.0015 and the result added to 1.275. The square of the observed weight was then multiplied by 0.0000125 and the result subtracted from the result of the first computation to obtain the adjustment factor. The adjustment factor was multiplied by the average of the three observed backfat measurements and the result was the adjusted backfat.

The backfat adjustment can be summarized as follows: Adjustment factor = observed weight x 0.0015 + 1.275 - observed weight^2 x 0.0000125. Adjustment factor x average observed backfat = adjusted backfat.

Loin eye area adjustment

The difference between the observed weight and 220 pounds was multiplied by 0.015. The result was added to the average loin eye area observed in pigs weighing less than 220 pounds and subtracted from the average loin eye area in those weighing more than 220 pounds.

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[1]Cooperative Extension Service, Iowa State University, Ames, Iowa.

Ham weight as a percentage of live weight adjustment

The percentage of live weight that was represented by hams was determined by dividing the total weight of both hams of each pig by the observed weight of the pig. The difference between the observed weight and 220 pounds was then multiplied by 0.03 to obtain an adjustment factor. The adjustment factor was subtracted from the observed ham percentage of pigs weighing under 220 pounds and added to the observed ham percentage of pigs weighing over 220 pounds.

Calculating the degree of muscling index

The degree of muscling index was calculated from the adjusted data by the use of the following procedure. The adjusted loin eye area multiplied by 8 and the adjusted ham percentage multiplied by 5 were added together. The adjusted backfat measurement multiplied by 20 was then subtracted from the total of the first computations. The remainder of this subtraction was taken as the degree of muscling index. The results of the degree of muscling index calculations are tabulated in Table 3.

Data Analysis

All data from clinical chemistry determinations, synovial fluid volume and cell counts, numerical values of gross and microscopic lesions, history, and carcass parameters were analyzed. Mean values

Table 3. Breed, identification number, sex, weight, backfat measurement, loin eye measurement, percentage of live weight due to ham, and degree of muscling index of 33 pigs

Breed,[a] pig No. and sex[c]	Weight[b] (lbs.)	Backfat[b] (inches)	Loin eye area[b] (sq. in.)	Ham[b] (% of weight)	Index
H65-34B	113	1.00	3.9	17.22	82.3
Y16-04B	184	1.22	5.0	14.43	82.6
H20-02B	181	.83	4.4	13.81	84.2
H65-50B	212	1.10	4.7	14.41	87.1
H19-02B	184	.92	4.9	14.26	89.1
H20-05B	155	.77	4.3	15.00	89.3
Y16-02G	205	1.38	5.4	15.24	89.6
H19-01B	196	1.07	5.2	14.54	90.5
Y16-03G	191	1.25	5.3	16.04	93.4
H65-31B	222	1.05	4.8	15.15	93.5
H12-10B	142	.73	4.4	15.72	93.7
Y16-01G	202	1.25	5.4	15.96	95.9
H20-08G	117	.52	4.0	16.17	96.0
H19-05G	165	.82	5.2	15.23	96.5
H65-33B	141	.85	4.8	16.84	98.8
H65-53B	196	.80	5.3	15.12	100.2
H19-03B	170	.77	5.7	14.78	100.4
H20-01B	248	1.13	5.6	15.09	101.7
Y13-70B	248	1.23	5.8	15.37	102.7
Y13-80G	170	.87	5.6	16.11	103.9
Y13-40G	236	1.17	6.1	15.57	105.7
H20-03B	282	1.17	6.5	13.70	106.2
H65-33G	152	.90	5.6	17.26	107.2
H20-07G	248	1.02	6.4	14.86	108.7
Y13-60B	231	1.02	5.8	16.38	108.8
H65-30B	185	1.03	6.6	15.78	109.8
H65-62B	210	1.03	6.6	16.05	111.8
H20-06B	215	.82	6.2	15.81	111.9
H12-20B	183	1.02	6.7	16.93	114.7
H65-31G	175	.97	6.7	17.74	120.8
H65-40G	198	.77	7.9	17.40	133.3
H09-06B	421	1.37	9.1	16.09	139.4
H09-07G	399	1.66	10.8	16.92	154.3

[a]H = Hampshire. Y = Yorkshire.

[b]Values observed at time of postmortem examination.

[c]B = Male. G = Female.

for each parameter and range (where appropriate) were calculated. Significance of differences between group means was determined by use of the least significant difference (LSD).

RESULTS

Clinical and Gross Lesion Observations

All pigs were observed at frequent intervals for the entire duration of the experiment and all clinical signs of lameness were recorded.

Data compiled from the appraisal of gross lesion observations and its statistical evaluation are presented in table form. Total values (means) and ranges are tabulated for the five study groups of swine in Table 4, and for the same pigs grouped by history of lameness in Table 5.

Hampshire control group

The six Hampshire control animals remained clinically normal throughout the experiment. A total of 48 designated joints was examined in this group and only minor gross lesions were observed at necropsy. There was brownish yellow discoloration of the synovial membrane in three joints and brownish yellow synovial fluid in two other joints. In addition, synovial fluid of both femorotibial joints of one pig that appeared clinically normal was increased in volume and serosanguineous.

Yorkshire control group

Two of eight Yorkshire control animals were slightly lame for a few days two to three weeks prior to necropsy; none were lame immediately

Table 4. Total values (means) of the gross lesions[a] in eight joints of each animal in five study groups of swine

Animal group	Animal weight (lbs.)	No. animals	Means[b]	Range
Hampshires (controls)	181-248	6	20.0	16-28
Hampshires (shaken - 4 days)	152-222	6	20.6	16-28
Hampshires (shaken - 11 days)	117-282	6	22.7	16-31
Yorkshires (controls)	170-248	8	20.6	16-31
Hampshires (spontaneously lame)	113-421	7	24.0	16-36

[a]Gross lesion observations as evaluated on a scale of 2 to 8. Normal = 2. Most severe = 8.

[b]Least significant difference = 4.2.

Table 5. Total values (means) of the gross lesions[a] in eight joints of each animal in swine grouped by history of lameness

Animal group	Animal weight (lbs.)	No. animals	Means[b]	Range
Never lame	170-248	12	20.7	16-31
Mild lameness	117-282	9	21.2	16-28
Moderate lameness	142-231	6	23.0	16-36
Severe lameness	113-421	6	24.0	18-31

[a]Gross lesion observations as evaluated on a scale of 2 to 8. Normal = 2. Most severe = 8.

[b]Least significant difference = 4.2.

prior to necropsy. A total of 64 designated joints were examined in this group. The synovial membranes of ten joints had gross lesions. These lesions were brownish yellow discoloration in seven, hyperemia in two, fibrosis in two, and villous hypertrophy in one joint. The synovial fluid was brownish yellow in 12 joints and serosanguineous in seven other joints.

Hampshires shaken four days prior to necropsy

Two of six pigs in the group of Hampshires examined four days after shaking exhibited a mild shifting lameness one to two months prior to shaking. One of these two pigs was lame in both posterior limbs on the day of shaking. Each pig in this group had a slight lameness of three days duration immediately following the 15 minute period of shaking. Most of the pigs had returned to normal on the day of necropsy.

Thirteen of the 48 joints examined in this group had gross lesions in the synovial membranes. These lesions were hyperemia in eight, brownish yellow discoloration in three and villous hypertrophy in two joints. The synovial fluid was brownish yellow in eight joints and serosanguineous in four other joints.

Hampshires shaken 11 days prior to necropsy

Five of the six pigs in this group remained clinically normal until after the 15 minute period of shaking. The remaining pig began an abnormal flexing of the radio-carpal joints while in a standing position

about 74 days prior to necropsy. This condition gradually improved and the pig had returned to normal by the time of shaking.

After shaking, five of the six pigs were slightly lame for two or three days but had returned to normal at the time of necropsy. The pig that had exhibited the abnormal flexing of the radio-carpal joints became lame in all four limbs the day after shaking. Three days after shaking the pig was having difficulty in arising from a prone position. This condition persisted until the day of necropsy.

Gross lesions were observed in the synovial membranes of 16 of the 48 joints examined in this group; four of these lesions were in the pig that had a history of abnormal flexing of the radio-carpal joints. These lesions were hyperemia in ten, villous hypertrophy in three, and brownish yellow discoloration in three joints. The synovial fluid was serosanguineous in seven joints and brownish yellow in seven other joints. There was also a marked increase in synovial fluid volume in one of the joints with serosanguineous fluid.

Hampshires - spontaneously lame

All pigs in the spontaneously lame group of Hampshires had a history of lameness with a duration that ranged from one day to several months. All were lame on the day of necropsy. Gross lesions were observed in the synovial membranes of 21 of the 56 joints examined in this group. These lesions were brownish yellow discoloration in 14, hyperemia in nine, villous hypertrophy in four, and edema in one joint. The synovial fluid was serosanguineous in eight joints, brownish yellow

in seven other joints, and turbid in two joints. There was an increase in synovial fluid volume in 20 joints.

In order to facilitate discussion of the results, the Hampshires shaken four days prior to necropsy and the Hampshires shaken 11 days prior to necropsy will be referred to as Hampshires (shaken - 4 days) and Hampshires (shaken - 11 days), respectively.

Comparison of gross lesion values

Group means of the total values of gross lesion scores from eight joints of each animal in the five study groups are presented in Table 4. Gross lesion scores of spontaneously lame Hampshires tended to be higher than gross lesion scores of the other three groups of Hampshires although statistical significance was not achieved. An increase in values without statistical significance was also evident in the history of lameness groupings. The severely lame group had higher values when compared with never lame, mildly lame, and moderately lame groups (Table 5).

Clinical Chemistry

Total lactic dehydrogenase (LDH)

Means and ranges of the total synovial fluid LDH activity in swine from five study groups are presented in Table 6. Synovial fluid LDH activity was significantly greater in swine from the spontaneously lame group of Hampshires than in any of the other four groups. Mean values

Table 6. Total synovial fluid LDH activity[a] (mean) in five study groups of swine

Animal group	Animal weight (lbs.)	No. animals	No. observations	Mean[b] activity	Range
Hampshires (controls)	181-248	6	39	216	100-380
Hampshires (shaken - 4 days)	152-222	6	37	233	100-360
Hampshires (shaken - 11 days)	117-282	6	37	200	60-350
Yorkshires (controls)	170-248	8	45	227	60-650
Hampshires (spontaneously lame)	113-421	7	34	292	70-999

[a]Wroblewski units per ml. In this and subsequent tables, one unit of activity is defined as that amount of enzyme which will produce a decrease of 0.001 in optical density per minute per ml of synovial fluid through a 1 cm lightpath at wavelength of 340 nm at a temperature of 25° C.

[b]Least significant difference = 35.0.

obtained from synovial fluid of the two shaken groups of Hampshires were not significantly different from those obtained from Hampshire or Yorkshire control swine.

Comparisons of total synovial fluid LDH activity means were also made on the same 33 pigs grouped by history of lameness (Table 7). Total synovial fluid LDH activity was significantly greater in both the moderately lame and the severely lame groups than in either the never lame or mildly lame groups.

A third comparison of total synovial fluid LDH activity was made between individual joints grouped as normal or as arthritic (Table 8). There was an increase in synovial fluid LDH activity in the arthritic joints but statistical significance was not achieved.

LDH isoenzyme distribution

LDH isoenzyme electrophoregrams were obtained by densitometrically scanning dried cellulose acetate membranes. Isoenzyme percentages were determined from these electrophoregrams. The group means and least significant differences were then determined (Tables 9, 10, 11).

Comparison of the two shaken groups of Hampshires with the Hampshire controls was made to study the effect of artificial stressing on synovial fluid LDH isoenzyme distribution. Isoenzyme 5 activity was significantly greater in Hampshires (shaken - 4 days) than in Hampshire controls. However, there was no difference in the level of isoenzyme 5 activity between Hampshires (shaken - 11 days) and Hampshire controls. Although

Table 7. Total synovial fluid LDH activity[a] (mean) in swine grouped by history of lameness

Animal group	Animal weight (lbs.)	No. animals	No. observations	Mean[b] activity	Range
Never lame	170-248	12	72	224	60-650
Mild lameness	117-282	9	52	195	60-350
Moderate lameness	142-231	6	37	318	140-999
Severe lameness	113-421	6	43	233	70-380

[a] Wroblewski units per ml.

[b] Least significant difference = 35.0.

Table 8. Total synovial fluid LDH activity[a] (mean) in individual joints grouped as normal or arthritic in 33 swine

Joint classification	No. observations	Mean[b] activity	Range
Normal	95	210	60-650
Arthritic	109	258	70-999

[a]Wroblewski units per ml.

[b]Least significant difference = 65.

Table 9. Mean distribution (%) of synovial fluid LDH isoenzymes in five study groups of swine

Animal group	Animal weight (lbs.)	Isoenzymes[a]				
		5	4	3	2	1
Hampshires (controls)	181-248	10.8	17.7	24.8	18.7	28.0
Hampshires (shaken - 4 days)	152-222	17.5	17.5	23.1	20.0	21.9
Hampshires (shaken - 11 days)	117-282	10.3	17.8	23.7	19.8	28.4
Yorkshires (controls)	170-248	14.7	19.8	25.2	19.9	20.4
Hampshires (spontaneously lame)	113-421	16.1	18.5	22.4	16.3	26.7

[a] Least Significant difference = 6.0.

Table 10. Mean distribution (%) of synovial fluid LDH isoenzymes of swine grouped by history of lameness

Animal group	Animal weight (lbs.)	No. Animals	Isoenzymes[a]				
			5	4	3	2	1
Never lame	170-248	12	12.6	18.6	24.6	19.4	24.8
Mild lameness	117-282	9	13.9	18.5	23.6	19.5	24.5
Moderate lameness	142-231	6	13.0	17.6	23.6	20.6	25.2
Severe lameness	113-421	6	17.9	18.6	23.2	15.5	24.8

[a]Least significant difference = 6.0.

Table 11. Mean distribution (%) of synovial fluid LDH isoenzymes in individual joints grouped as normal or arthritic in 33 swine

Joint classification	No. observations	Isoenzymes[a]				
		5	4	3	2	1
Normal	77	13.5	17.9	24.0	19.2	25.4
Arthritic	98	13.5	18.3	24.0	18.0	26.2

[a]Least significant difference = 7.4.

there was a difference in isoenzyme 5 activity between spontaneously lame Hampshires and Hampshire controls, the difference was not statistically significant. Isoenzyme 5 activity in Yorkshire controls was not significantly greater than in Hampshire controls.

Two groups, Hampshires (shaken - 4 days) and Yorkshire controls, had significantly lower mean levels of LDH isoenzyme 1 activity than either Hampshire controls or Hampshires (shaken - 11 days). Spontaneously lame Hampshires had greater LDH isoenzyme 1 activity than Yorkshire controls. There were no significant differences between any of the groups in levels of LDH isoenzymes 2, 3, or 4.

When the pigs were grouped by history of lameness, there were no significant differences in the mean activity of any of the LDH isoenzymes between any of the groups.

Comparisons of LDH isoenzyme distribution between individual joints grouped as normal or arthritic did not reveal any differences in the mean activity of any of the isoenzymes.

Total serum protein levels

Group means of total serum protein levels were determined and the least significant difference was established (Tables 12 and 13). Mean serum protein levels in spontaneously lame Hampshires were significantly greater than levels in either Yorkshire controls or Hampshires (shaken - 4 days). There was a difference in the serum protein levels between Hampshire controls and Yorkshire controls, however, this

Table 12. Total serum protein levels (mean) in five study groups of swine

Animal group	Animal weight (lbs.)	No. animals	No. observations	Mean[a] (gm/100 ml)	Range
Hampshires (controls)	181-248	6	6	6.67	5.1 - 7.4
Hampshires (shaken - 4 days)	152-222	6	6	6.07	5.6 - 6.4
Hampshires (shaken - 11 days)	117-282	6	6	6.67	5.4 - 7.6
Yorkshires (controls)	170-248	8	8	6.02	5.5 - 6.4
Hampshires (spontaneously lame)	113-421	7	7	6.97	5.7 - 7.9

[a]Least significant difference = 0.8.

Table 13. Total serum protein levels (mean) in swine grouped by history of lameness

Animal group	Animal weight (lbs.)	No. Animals	No. observations	Mean[a] (g/ 100 ml)	Range
Never lame	170-248	12	12	6.31	5.1 - 7.4
Mild lameness	117-282	9	9	6.34	5.4 - 7.6
Moderate lameness	142-231	6	6	6.62	5.6 - 7.6
Severe lameness	113-421	6	6	6.82	5.7 - 7.9

[a] Least significant difference = 0.7.

difference was not statistically significant.

No significant differences in mean serum protein levels were observed in swine grouped by history of lameness.

Total synovial fluid protein levels

Group means of total synovial fluid protein levels were determined and least significant differences were established (Tables 14, 15, and 16).

No statistically significant differences in mean synovial fluid protein levels were observed in the five study groups or in the swine grouped by history of lameness.

When synovial fluid protein levels of individual joints grouped as normal or arthritic were compared, levels in arthritic joints were significantly greater.

Distribution of serum and synovial fluid protein fractions

Electrophoregrams of protein fraction distribution in serum and synovial fluid were obtained by densitometrically scanning dried cellulose acetate membranes. Fraction percentages were determined from these electrophoregrams. The group means and least significant differences were then calculated (Tables 17-21).

In the five study groups of swine, the percentage of serum gamma globulin of Hampshires (shaken - 4 days), Hampshires (shaken - 11 days), and spontaneously lame Hampshires was not significantly different from

Table 14. Total synovial fluid protein levels (mean) in five study groups of swine

Animal group	Animal weight (lbs.)	No. Animals	No. observations	Mean[a] (gm/100 ml)	Range
Hampshires (controls)	181-248	6	29	1.83	1.0 - 2.7
Hampshires (shaken - 4 days)	152-222	6	25	1.92	0.8 - 2.9
Hampshires (shaken - 11 days)	117-282	6	22	1.94	1.0 - 2.9
Yorkshires (controls)	170-248	8	39	1.64	0.7 - 2.9
Hampshires (spontaneously lame)	113-421	7	33	2.19	1.0 - 3.3

[a]Least significant difference = 0.8.

Table 15. Total synovial fluid protein levels (mean) in swine grouped by history of lameness

Animal group	Animal weight (lbs.)	No. Animals	No. observations	Mean[a] (gm/ 100 ml)	Range
Never lame	170-248	12	58	1.72	0.7 - 2.9
Mild lameness	117-282	9	31	1.79	1.0 - 2.9
Moderate lameness	142-231	6	22	2.03	0.8 - 3.3
Severe lameness	113-421	6	37	2.16	0.8 - 2.9

[a]Least significant difference = 0.8.

Table 16. Total synovial fluid protein levels (mean) in individual joints grouped as normal or arthritic in 33 swine

Joint classification	No. observations	Mean[a] (gm/100 ml)	Range
Normal	64	1.60	0.7 - 2.7
Arthritic	84	2.11	0.8 - 3.3

[a]Least significant difference = 0.42.

Table 17. Mean distribution (%) of serum protein fractions of five study groups of swine

Animal group	Animal weight (lbs.)	No. observations	Fractions[a]				
			Albumin	Globulins			
				α_1	α_2	β	γ
Hampshires (controls)	181-248	6	28.1	7.2	16.8	23.4	24.5
Hampshires (shaken - 4 days)	152-222	6	29.3	6.2	16.6	23.8	24.1
Hampshires (shaken - 11 days)	117-282	6	26.6	7.2	18.2	24.0	24.0
Yorkshires (controls)	170-248	8	30.3	7.4	20.1	24.6	17.6
Hampshires (spontaneously lame)	113-421	7	27.5	6.8	18.0	22.1	25.6

[a]Least significant difference = 6.3.

Table 18. Mean distribution (%) of serum protein fractions of swine grouped by history of lameness

Animal group	Animal weight (lbs.)	No. observations	Fractions[a]				
			Albumin	Globulins			
				α_1	α_2	β	γ
Never lame	170-248	12	28.9	7.2	18.4	24.4	21.1
Mild lameness	117-282	9	29.0	6.7	17.7	24.2	22.4
Moderate lameness	142-231	6	27.0	7.8	17.3	22.5	25.4
Severe lameness	113-421	6	27.9	6.0	18.8	21.5	25.8

[a]Least significant difference = 6.0.

Table 19. Mean distribution (%) of synovial fluid protein fractions of five study groups of swine

Animal group	Animal weight (lbs.)	No. observations	Fractions[a]				
			Albumin	Globulins			
				α_1	α_2	β	γ
Hampshires (controls)	181-248	34	38.5	9.4	13.7	21.5	16.9
Hampshires (shaken - 4 days)	152-222	33	39.4	10.7	11.5	22.1	16.3
Hampshires (shaken - 11 days)	117-282	31	42.0	9.7	12.8	19.9	15.6
Yorkshires (controls)	170-248	36	42.8	9.1	11.6	23.8	12.7
Hampshires (spontaneously lame)	113-421	43	36.8	8.0	12.4	22.8	20.0

[a] Least significant difference = 5.2.

Table 20. Mean distribution (%) of synovial fluid protein fractions in swine grouped by history of lameness

Animal group	Animal weight (lbs.)	No. observations	Fractions[a]				
				Globulins			
			Albumin	α_1	α_2	β	γ
Never lame	170-248	63	40.0	9.0	13.0	22.0	16.0
Mild lameness	117-282	45	43.6	8.9	12.6	21.6	13.3
Moderate lameness	142-231	30	37.5	8.2	13.5	22.9	17.9
Severe lameness	113-421	39	36.5	9.9	11.1	21.5	21.0

[a]Least significant difference = 4.8.

Table 21. Mean distribution (%) of synovial fluid protein fractions in individual joints grouped as normal or arthritic in 33 swine

Joint classification	No. observations	Fractions[a]				
			Globulins			
		Albumin	α_1	α_2	β	γ
Normal	78	42.6	9.0	12.2	21.4	14.8
Arthritic	99	40.1	8.6	12.2	22.5	16.6

[a]Least significant difference = 5.2.

that observed in Hampshire controls. However, the percentage of serum gamma globulin was significantly greater in all four of the Hampshire groups than in Yorkshire controls.

There were no significant differences in mean distribution percentages of albumin and beta, alpha-2, and alpha-1 globulin fractions between any of the five groups.

When the pigs were grouped by history of lameness, no significant differences in mean distribution percentages of any of the serum protein fractions were observed.

In the five study groups of swine there was no significant difference in the percentage of gamma globulin in synovial fluid between any of the Hampshire groups and Hampshire controls. There was a significantly greater percentage of synovial fluid gamma globulin in the spontaneously lame Hampshires than in Yorkshire controls. The albumin fraction percentage in the synovial fluid of spontaneously lame Hampshires was significantly less than in either Yorkshire controls or Hampshires (shaken - 11 days).

When the pigs were grouped by history of lameness, the mean distribution of synovial fluid gamma globulin was significantly greater in the severely lame group than in either never lame or mildly lame groups, but not in moderately lame pigs. The albumin fraction percentage was significantly less in severely lame and moderately lame groups than in the mildly lame group (Table 20).

Comparisons of synovial fluid protein fraction distribution in

arthritic joints with that in normal joints indicated a slight increase in gamma globulin and decreased albumin, but these differences were not statistically significant (Table 21).

Total cell counts per ml of synovial fluid

Group means and least significant differences were determined for total cell counts per mm^3 of synovial fluid (Tables 22, 23, and 24). Mean cell counts in the synovial fluid of spontaneously lame Hampshires were significantly greater than those in Hampshire controls, Hampshires (shaken - 4 days), and Hampshires (shaken - 11 days), but not Yorkshire controls.

In the groupings by history of lameness, synovial fluid mean cell counts were significantly greater in severely lame pigs than in the never lame and mildly lame groups, but not the moderately lame group. Comparison of mean total cell counts in the synovial fluid of arthritic joints with those of normal joints disclosed a statistically significant increase in the arthritic joints (Table 24).

Volume of synovial fluid

Group means and least significant differences were determined for total volume of synovial fluid aspirated from eight joints of each pig. Group means and least significant differences were also calculated for the volume of synovial fluid aspirated from individual joints grouped as either normal or arthritic (Tables 25, 26, and 27).

Table 22. Total cell counts (mean) per mm^3 of synovial fluid in five study groups of swine

Animal group	Animal weight (lbs.)	No. Animals	No. observations	Mean[a] count	Range
Hampshires (controls)	181-248	6	41	25	3-80
Hampshires (shaken - 4 days)	152-222	6	41	76	23-213
Hampshires (shaken - 11 days)	117-282	6	40	32	0-95
Yorkshires (controls)	170-248	8	46	129	27-330
Hampshires (spontaneously lame)	113-421	7	51	184	0-990

[a]Least significant difference = 75.

Table 23. Total cell counts (mean) per mm^3 of synovial fluid in swine grouped by history of lameness

Animal group	Animal weight (lbs.)	No. animals	No. observations	Mean[a] counts	Range
Never lame	170-248	12	75	75	3-330
Mild lameness	117-282	9	59	50	0-247
Moderate lameness	142-231	6	38	119	0-467
Severe lameness	113-421	6	46	175	0-990

[a]Least significant difference = 75.

Table 24. Total cell counts per mm^3 of synovial fluid in individual joints grouped as normal or arthritic in 33 swine

Joint classification	No. observations	Mean[a] count	Range
Normal	107	66	0.0 - 330
Arthritic	111	127	0.0 - 990

[a]Least significant difference = 43

Table 25. Total volume (mean) of synovial fluid aspirated from eight joints of each pig in five study groups of swine

Animal group	Animal weight (lbs.)	No. animals	Mean[a] (mls)	Range
Hampshires (controls)	181-248	6	6.55	4.0 - 9.6
Hampshires (shaken - 4 days)	152-222	6	7.25	2.0 - 11.8
Hampshires (shaken - 11 days)	117-282	6	7.63	3.3 - 15.2
Yorkshires (controls)	170-248	8	7.25	3.3 - 11.8
Hampshires (spontaneously lame)	113-421	7	13.31	3.8 - 30.0

[a]Least significant difference = 4.6.

Table 26. Total volume (mean) of synovial fluid aspirated from eight joints of each pig in swine grouped by history of lameness

Animal group	Animal weight (lbs.)	No. animals	Mean[a] (mls)	Range
Never lame	170-248	12	7.07	4.0 - 11.8
Mild lameness	117-282	9	6.32	2.0 - 11.8
Moderate lameness	142-231	6	7.10	3.3 - 12.2
Severe lameness	113-421	6	15.90	3.8 - 30.0

[a]Least significant difference = 4.6.

Table 27. Volume (mean) of synovial fluid aspirated from individual joints grouped as either normal or arthritic in 33 swine

Joint classification	No. observations	Mean[a] (mls)	Range
Normal	144	0.63	0.0 - 3.0
Arthritic	120	1.58	0.0 - 6.5

[a]Least significant difference = .52.

The mean total volume of synovial fluid of spontaneously lame Hampshires was significantly greater than in any of the other four groups. When the pigs were grouped by history of lameness, the severely lame group had significantly higher synovial fluid total volume than did the never lame, mildly lame, or moderately lame groups (Table 26). Comparison of the mean volume of synovial fluid in individual arthritic joints with that in normal joints revealed a statistically significant increase in the arthritic joints (Table 27).

Microscopic lesion evaluations

Group means of the evaluations of lesions A, B, and C (Figures 10-15) were determined and the least significant differences established (Tables 28, 29, and 30).

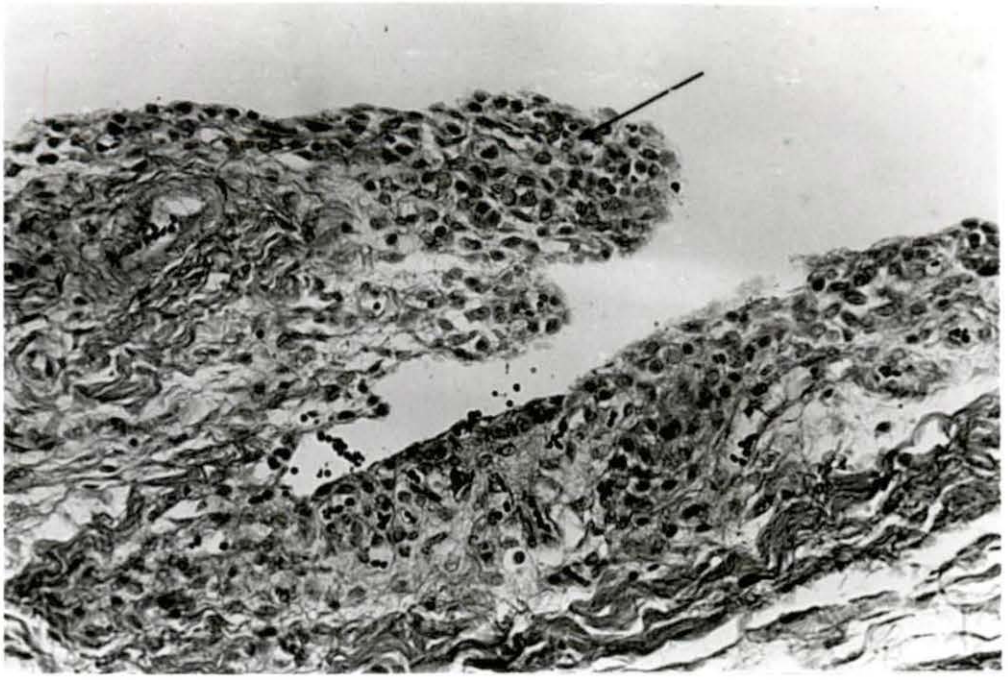
The mean evaluations of lesion A in spontaneously lame Hampshires were significantly greater than those in the other four of the five study groups. Mean evaluations of lesion B in spontaneously lame Hampshires were significantly greater than those in Hampshire controls, Yorkshire controls, and Hampshires (shaken - 4 days). Mean evaluations of lesion C were significantly greater in spontaneously lame Hampshires than in Yorkshire controls and Hampshires (shaken - 4 days). In addition, there was an increase in values of lesion C in spontaneously lame Hampshires compared with Hampshire controls and Hampshires (shaken - 11 days).

The mean evaluations of lesion A in the severely lame group were significantly greater than in the never lame group and there was a non-statistically significant increase over the mildly lame and moderately

Lesion A

Figure 10. Lining cell hyperplasia of the synovial membrane (arrow) X 240

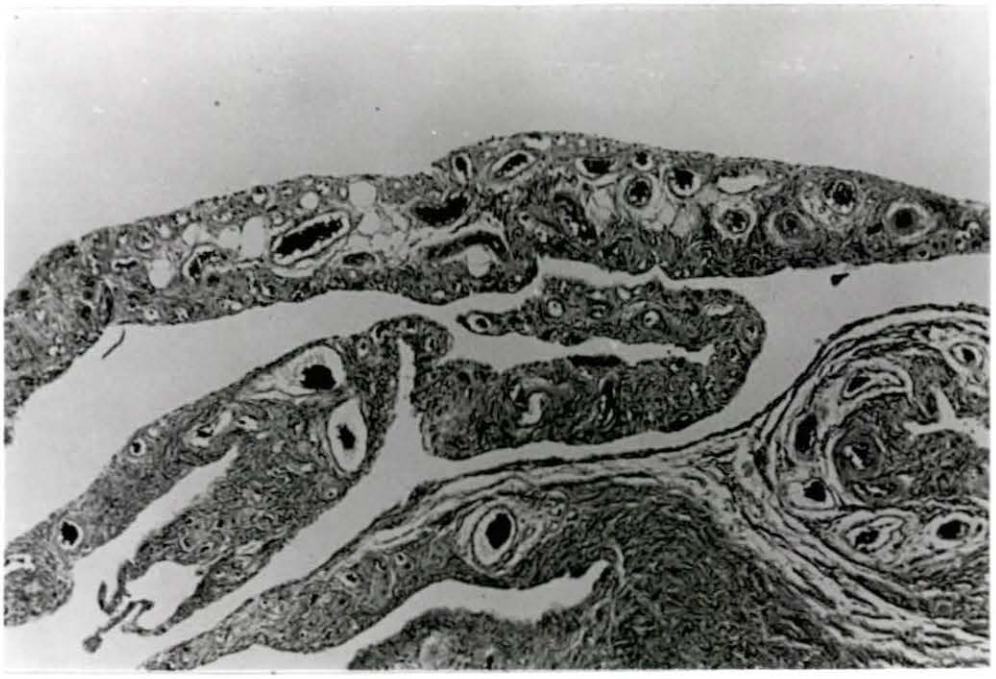
Figure 11. Villous hypertrophy of the synovial membrane X 20

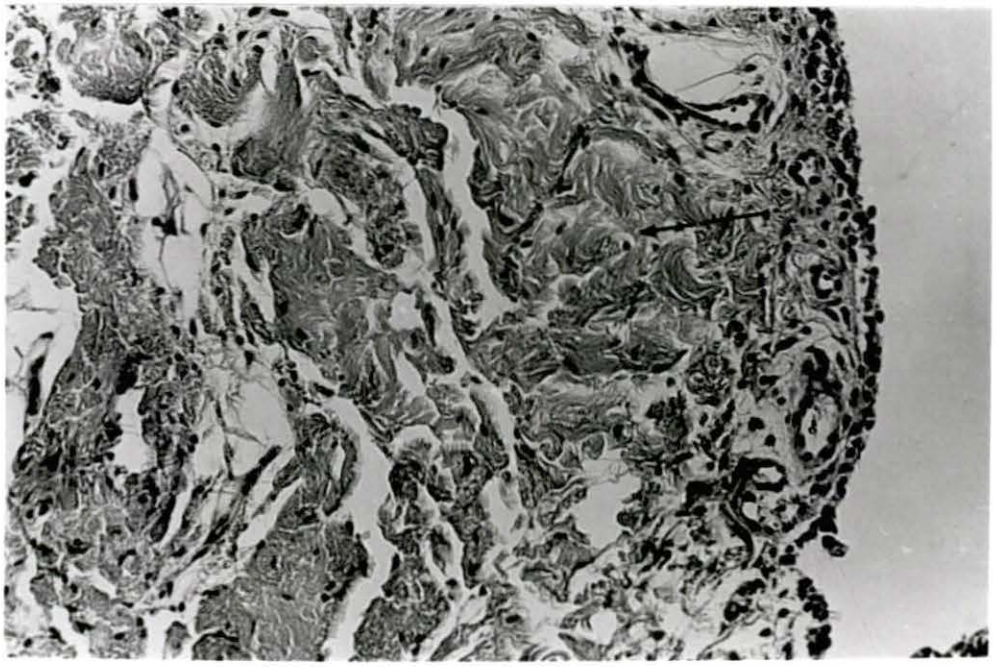


Lesion B

Figure 12. Vascular proliferation of the synovial membrane X 72

Figure 13. Fibrosis of the synovial membrane (arrow) X 180

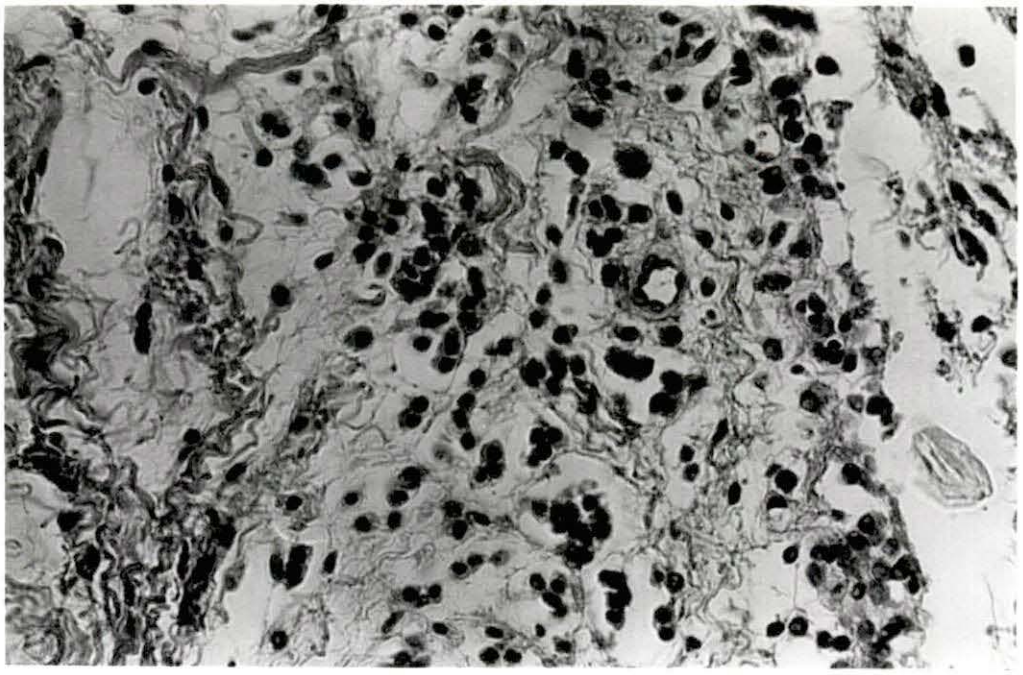




Lesion C

Figure 14. Synovial membrane. Note focus of lymphocytes and plasma cells X 375

Figure 15. Synovial membrane. Note perivascular infiltration of lymphocytes and plasma cells (arrow) X 240



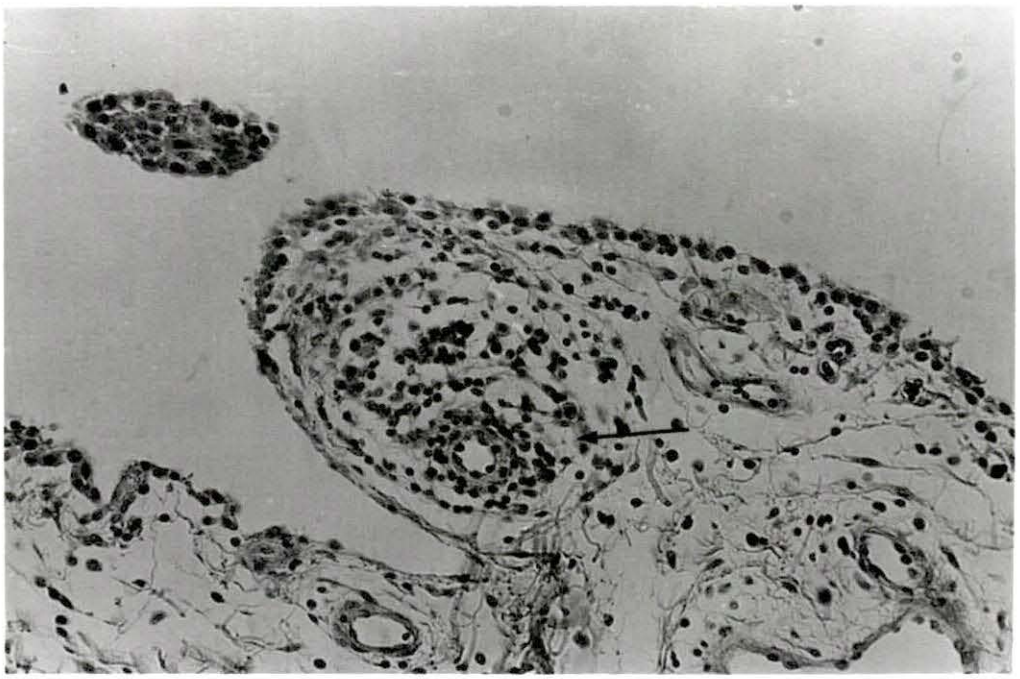


Table 28. Means[a] of microscopic lesion evaluations in the synovial membranes in eight joints of five study groups of swine

Animal group	Animal weight (lbs.)	No. Animals	Means lesion-A[b]	Means lesion-B[c]	Means lesion-C[d]
Hampshires (controls)	181-248	6	61.5	52.3	35.0
Hampshires (shaken - 4 days)	152-222	6	62.2	54.5	32.8
Hampshires (shaken - 11 days)	117-282	6	66.2	59.5	34.8
Yorkshires (controls)	170-248	8	65.1	54.0	33.0
Hampshires (spontaneously lame)	113-421	7	82.0	64.4	42.7

[a]Least significant difference = 9.0.

[b]Lesion A = Lining cell hyperplasia and villous hypertrophy.

[c]Lesion B = Vascular proliferation and fibrosis.

[d]Lesion C = Foci and perivascular infiltration of inflammatory cells.

Table 29. Means[a] of microscopic lesion evaluations in the synovial membranes in eight joints of swine grouped by history of lameness

Animal group	Animal weight (lbs.)	No. animals	Means lesion-A[b]	Means lesion-B[c]	Means lesion-C[d]
Never lame	170-248	12	64.1	54.0	34.1
Mild lameness	117-282	9	66.8	58.0	34.1
Moderate lameness	142-231	6	69.5	54.2	38.7
Severe lameness	113-421	6	73.3	63.2	37.8

[a]Least significant difference = 9.6.

[b]Lesion A = Lining cell hyperplasia and villous hypertrophy.

[c]Lesion B = Vascular proliferation and fibrosis.

[d]Lesion C = Foci and perivascular infiltration of inflammatory cells.

Table 30. Means[a] of microscopic lesion evaluations in the synovial membranes of individual joints grouped as either normal or arthritic in 33 swine

Joint classification	No. observations	Means lesion-A[b]	Means lesion-B[c]	Means lesion-C[d]
Normal	144	8.25	6.85	4.39
Arthritic	120	8.72	7.45	4.55

[a]Least significant difference = 1.20.

[b]Lesion A = Lining cell hyperplasia and villous hypertrophy.

[c]Lesion B = Vascular proliferation and fibrosis.

[d]Lesion C = Foci and perivascular infiltration of inflammatory cells.

lame groups. Mean evaluations of lesion B revealed that values in the severely lame group were higher than the other three groups, but this difference was not statistically significant (Table 29).

When individual joints were grouped as normal or arthritic, there was an increase in values in lesions A, B, and C, for the arthritic joints compared with the normal joints, but statistical significance was not achieved (Table 30).

Results of Microscopic Examination of Articular Cartilage, Bone and Other Tissues

The great majority of histological tissue sections of both weight bearing and nonweight bearing articular cartilages appeared normal when examined microscopically. There were a few areas of endochondral vascular degeneration but this was considered to be normal in growing swine. One of the Yorkshire controls had an area of flaking on the nonweight bearing surface of the femoral trochlea. There was an area of erosion of the tangential layer of the weight bearing articular cartilage of the left femoral condyle in one of the spontaneously lame Hampshires.

No microscopic lesions were observed in tissue sections of bone, lung, liver, spleen, kidney, and lymph nodes taken from any of the 33 experimental swine.

Degree of muscling index

Group means of the degree of muscling index were determined and least significant differences established (Tables 31 and 32).

The mean degree of muscling index in the spontaneously lame Hampshires was significantly greater than that of Yorkshire controls or Hampshires (shaken - 4 days). When the pigs were grouped by history of lameness the mean degree of muscling index was significantly greater in the severely lame group than in the mildly lame group but not in the never lame or moderately lame groups.

Microbiological Findings

A total of 363 sites in the 33 experimental swine were cultured for mycoplasmas and bacteria. These included 66 mucosal surfaces, 33 tonsils, and 264 intraarticular sites. Bacteria were recovered as follows: Two Acholeplasma sp. isolates from nasopharyngeal mucosa; four Micrococuss sp., two colonies of various bacteria and two unidentified isolates from normal joints; and one Micrococcus sp. isolate from an arthritic joint. All tonsils were negative for both Erysipelothrix rhusiopathiae and mycoplasmas. Details of the microbiological results are presented in Table 33.

Table 31. Degree of muscling index (mean) in five study groups of swine

Animal group	Animal weight (lbs.)	No. animals	Mean[a] index	Range
Hampshires (controls)	181-248	6	106.2	84.2 - 133.3
Hampshires (shaken - 4 days)	152-222	6	95.6	87.1 - 107.2
Hampshires (shaken - 11 days)	117-282	6	101.1	90.5 - 111.8
Yorkshires (controls)	170-248	8	97.8	82.6 - 108.8
Hampshires (spontaneously lame)	113-421	7	114.9	82.3 - 154.3

[a]Least significant difference = 15.2.

Table 32. Degree of muscling index (mean) in swine grouped by history of lameness

Animal group	Animal weight (lbs.)	No. animals	Mean[a] index	Range
Never lame	170-248	12	100.7	82.6 - 133.3
Mild lameness	117-282	9	96.7	87.1 - 106.2
Moderate lameness	142-231	6	106.5	93.5 - 120.8
Severe lameness	113-421	6	114.5	82.3 - 154.3

[a]Least significant difference = 15.2.

Table 33. Mycoplasmas and bacteria isolated from the nasopharyngeal and oral mucosae, tonsil and joints of 33 pigs

Pig No.	Nasopharynx[a]	Tonsil[b]	Normal joints[c]	Arthritic joints[c]
H19-02B	0/2[d]	0/1	0/7	0/1
H20-02B	0/2	0/1	0/8	0/0
H20-06B	0/2	0/1	0/4	0/4
H20-07G	0/2	0/1	0/4	0/4
H65-30B	0/2	0/1	0/7	0/1
H65-40G	0/2	0/1	0/6	0/2
H19-05G	0/2	0/1	0/7	0/1
H20-05B	0/2	0/1	0/6	0/2
H65-31B	0/2	0/1	0/2	0/6
H65-33G	0/2	0/1	0/3	0/5
H65-50B	0/2	0/1	0/1	0/7
H65-53B	0/2	0/1	0/4	0/4
H19-01B	0/2	0/1	0/1	1/7[e]
H19-03B	0/2	0/1	0/0	0/8
H20-01B	2/2[f]	0/1	1/6[g]	0/2

[a]Mucosal surfaces cultured for mycoplasmas were palatine tonsil and nasopharynx.

[b]Incised tonsil cultured for mycoplasmas and minced tonsil cultured for Erysipelothrix rhusiopathiae.

[c]Synovial fluid from eight joints was cultured for mycoplasmas, aerobic bacteria and anaerobic bacteria.

[d]Number of specimens positive over number of sites cultured.

[e]Colonies of Micrococcus sp. on aerobic and anaerobic plates.

[f]Acholeplasma sp.

[g]Colonies of various bacteria.

Table 33. (continued)

Pig No.	Nasopharynx[a]	Tonsil[b]	Normal joints[c]	Arthritic joints[c]
H20-03B	0/2	0/1	1/4[g]	0/4
H20-08G	0/2	0/1	1/8[e]	0/0
H65-62B	0/2	0/1	0/0	0/8
Y13-40G	0/2	0/1	0/3	0/5
Y13-60B	0/2	0/1	1/6[e]	0/2
Y13-70B	0/2	0/1	0/6	0/2
Y13-80G	0/2	0/1	1/6[h]	0/2
Y16-01G	0/2	0/1	0/0	0/8
Y16-02G	0/2	0/1	1/6[h]	0/2
Y16-03G	0/2	0/1	0/3	0/5
Y16-04B	0/2	0/1	0/4	0/4
H09-06B	0/2	0/1	0/1	0/7
H09-07G	0/2	0/1	0/1	0/7
H12-10B	0/2	0/1	2/7[i]	0/1
H12-20B	0/2	0/1	0/0	0/8
H65-34B	0/2	0/1	0/2	0/6
H65-33B	0/2	0/1	0/4	0/4
H65-31G	0/2	0/1	0/4	0/4

[h]Colonies of Micrococcus sp. on anaerobic plate only.

[i]White colonies on anaerobic plate.

DISCUSSION

Lameness is common in heavily muscled swine reared in confinement on concrete floors. This lameness problem is being intensified by the rapid increase in use of confinement facilities for swine production. Another factor aggravating the problem may be selection of breeding stock of a genotype that is predisposed to leg problems and arthritis. Research workers at the Veterinary Medical Research Institute, Iowa State University, have observed an apparently noninfectious arthritis in swine that are reared in isolation units. Bollwahn (1967) described an arthrosis in experimental pigs which was not infectious and was similar to the disease encountered in this study.

Clinical, morphological, and clinical chemistry characteristics of an arthritis observed in swine utilized in the present study were considered typical of the above described nonseptic arthritis. On the basis of these observations, the following pathogenesis for the arthritis is proposed: Frequently repeated mild trauma to the articulation results in a tissue reaction in which, initially, there is periarticular swelling, increased synovial fluid, and hyperemia of the synovial membranes. During the early stages there is increased enzymatic activity and changes in metabolism. Synovial membrane permeability increases and there is a shift in protein fraction distribution and changes in cellular content of synovial fluid. Concurrently with these changes, gross and microscopic lesions appear. Gross changes begin with hyperemia of the

synovial membranes, later there is villous hypertrophy and then yellowish or brownish yellow discoloration of these tissues. Microscopic changes in the synovial membranes begin with hyperplasia of the lining cells and villous hypertrophy. Later there is vascular proliferation and foci of lymphocytes and plasma cells in the subsynovial tissues. Fibrosis may become evident in the later stages.

The clinical signs and lesions observed in spontaneously lame Hampshires from the study group classification, the severely and moderately lame pigs from the history of lameness classification, and individual arthritic joints were considered representative of the preceding hypothetical model of traumatic arthritis.

Spontaneously lame Hampshires had significantly higher total LDH activity in synovial fluid than Hampshire controls. This group also showed a shift toward anaerobic distribution of LDH isoenzymes although statistical significance was not achieved (Tables 6 and 9). Similar observations were made of total LDH and LDH isoenzyme parameters in the severely lame and moderately lame groups from the groupings by history of lameness.

When total LDH and LDH isoenzyme comparisons were made between synovial fluid from individual normal and arthritic joints, there was a slight increase in total LDH which was not statistically significant, but there were no differences in LDH isoenzyme distribution.

Vesell et al. (1962) and West et al. (1963) reported increased total LDH activity of synovial fluid in rheumatoid arthritis in man.

It appeared that this was due to increased LDH production by synovial lining cells and the contribution of increased numbers of leukocytes. Lindy et al. (1971) observed increased LDH activity in synovial tissue from human rheumatoid arthritis patients. Agostini and Vergani (1966) discussed the metabolic functions of the various LDH isoenzymes. An increase in isoenzyme 5 and a decrease in isoenzyme 1 were interpreted as an indication of increased anaerobic metabolism. Tushan et al. (1969) stated that 70% of the LDH isoenzyme distribution in articular cartilage is isoenzyme 4 and 5. It would appear that the increase in synovial fluid LDH activity and the shift toward anaerobic isoenzyme distribution in the spontaneously lame Hampshires, severely lame pigs, and moderately lame pigs was due to increased production by synovial membrane lining cells, an increase in synovial fluid cell count and, possibly, escape of anaerobic isoenzymes from damaged articular cartilage. However, in the present study, microscopic examination of sections of the bone underlying articular cartilage failed to reveal any changes that could be related to cartilage damage. The reason for the failure of anaerobic LDH isoenzyme distribution to appear in the individual arthritic joints is unknown.

Mean serum protein levels in spontaneously lame Hampshires were significantly greater than in Hampshires (shaken - 4 days). In addition, there was an increase in total serum protein when comparisons were made with Hampshire controls and Hampshires (shaken - 11 days), although this increase was not significant (Table 12). A nonsignificant increase in total serum protein was also observed in the severely lame and

moderately lame groups. This may indicate that there is a correlation between development of arthritis and an increase in serum protein levels.

In work with arthritis in swine due to Erysipelothrix rhusiopathiae, Papp and Sikes (1964) reported that serum protein increased as the pigs increased in age. Miller et al. (1961) found increased serum protein in swine as their age increased. Since the average age of the spontaneously lame Hampshires was about 40 days more than the average age of the other Hampshires, differences found in this aspect of the study may be hypothesized as being due to aging. This premise was seemingly valid for the severely lame pigs in which the average age was about 50 days more than the average age of the never lame and mildly lame. In contrast, however, the average age of the moderately lame pigs was about 10 days less than the average age of the never lame and mildly lame.

Mean synovial fluid protein levels in spontaneously lame Hampshires were not significantly greater than in the other Hamphire groups (Table 14). Neither were these levels significantly higher in severely lame or moderately lame pigs when compared with never lame or mildly lame (Table 15). However, there was an upward trend in synovial fluid protein levels in these arthritic groups. Comparison of synovial fluid protein levels in individual arthritic joints with normal joints disclosed a significant increase in the arthritic joints.

Elevations in synovial fluid protein have been reported in

erysipelatous arthritis by Crimmons and Sikes (1965) and Bollwahn (1967). Barthel (1970) found similar elevations in synovial fluid protein content in Mycoplasma hyorhinis-infected joints. In contrast, Bollwahn (1967) reported no increase in synovial fluid protein in hydroarthrosis of swine.

The trend toward increased synovial fluid protein levels in the arthritic groups in this study may indicate increased permeability of the synovial membrane vasculature which would allow increased diffusion of protein from the plasma.

The mean distribution (%) of serum protein fractions in the spontaneously lame Hampshires did not differ from that observed in the other Hampshire groups (Table 17). Papp and Sikes (1964) reported significantly increased levels of gamma and beta-2 globulins in erysipelatous arthritis of swine. Neher and Carter (1966) reported elevated serum gamma globulin levels and lowered serum albumin in swine erysipelas. White et al. (1968, p. 725) stated that there is an increase in gamma and alpha globulins in the sera of human patients with chronic rheumatoid arthritis. Significant elevation of serum gamma globulin was not observed in the spontaneously lame Hampshires, however, there was a tendency toward increased levels in the severely lame and moderately lame groups (Table 18). This increase in serum gamma globulin is in agreement with findings in swine erysipelas and rheumatoid arthritis in man. However, the increases in serum gamma globulin in swine erysipelas and rheumatoid arthritis in man were of much greater magnitude than the increases observed in the swine in this study.

The mean distribution (%) of synovial fluid protein fractions in spontaneously lame Hampshires showed an increase in gamma globulin and a reduction in albumin levels when compared with the three other Hampshire groups, although these differences did not prove to have statistical significance. Furthermore, gamma globulin in synovial fluid of the severely lame group was significantly higher than in the never lame and mildly lame groups. However, when individual joints were grouped as either normal or as arthritic, there were no significant differences in the distribution of synovial fluid protein fractions. Elevated gamma globulin in synovial fluid from arthritic joints in man originates in the plasma, but at least part may come from infiltrating lymphocytes and plasma cells present in inflamed synovial tissues (Wilkinson and Jones, 1962). Since synovial fluid gamma globulin in the severely lame groups was increased significantly and the spontaneously lame Hamphires had a similar increase in gamma globulin, it would appear that this increase originated from plasma. In support of this assumption is the fact that the severely lame group had an increase in serum gamma globulin. It is suggested that while the increase in cells in the synovial fluid and synovial membrane is significant, the magnitude of this increase is probably not sufficient to affect protein fraction distribution.

Total cell counts in the synovial fluid of the spontaneously lame Hampshires were significantly higher than the counts in the other three groups of Hampshires. Total synovial fluid cell counts were also

significantly higher in the severely lame group than in the never lame group and also significantly higher in individual arthritic joints than in normal joints. The mean count for spontaneously lame Hampshires was 184, for the severely lame group it was 175, and for individual arthritic joints it was 127. The mean cell count in Hampshire controls was 25 cells per mm^3 of synovial fluid. Bollwahn (1967) reported counts of up to 350 cells per mm^3 of synovial fluid from joints of pigs with hydroarthrosis. Coggeshall et al. (1940) observed an average count of 63 cells per mm^3 of synovial fluid from normal knee joints in man. The range in this study was 13 to 180 cells and these authors suggested that the variation in cell counts was the result of trauma from daily use. It is hypothesized that in this study of arthritis in swine, the increased cell counts in the spontaneously lame Hampshires, severely lame group, and arthritic joints are a reaction to trauma.

The volume of synovial fluid in the joints of the spontaneously lame Hampshires was significantly greater than that in the other three groups of Hampshires. Synovial fluid volume was also significantly higher in the severely lame group compared with the never lame group and significantly higher in arthritic joints than in normal joints. These observations of increased volume of synovial fluid were also considered to indicate increased vascular permeability and a response to trauma.

Total values of microscopic lesions A and B were significantly higher in the spontaneously lame Hampshires than in Hampshire controls.

There was also a marked increase in the total values of lesion C, although this increase was not statistically significant (Table 28). In a similar comparison of gross lesion evaluations, there was an increase in the spontaneously lame Hampshires but statistical significance was not achieved in that parameter. In the groupings by history of lameness, the severely lame group had significantly higher values for lesion B than the never lame group. In addition, there was a trend toward increasing values of lesions A and C in the severely lame compared with the other groups (Table 29).

There were slight increases in the total values of microscopic lesions A, B, and C in the arthritic joints compared with normal joints but these differences were not statistically significant (Table 30).

In the present study, clinical signs and microscopic lesion evaluations had a closer correlation than did clinical signs and gross lesion evaluations. These observations may indicate that microscopic lesions may be a better criterion for evaluation of arthritic joints than gross lesions.

It has been hypothesized that the degree of muscling has an influence on the susceptibility of swine to traumatic arthritis. Carcass data evaluations in this experiment tend to support that premise. The degree of muscling index for the spontaneously lame Hampshires was significantly greater than that of the Hampshires (shaken - 4 days) and there was an increase in the degree of muscling index when spontaneously lame Hampshires were compared with Hampshire controls and

Hampshires (shaken - 11 days) (Table 31). In the groupings by history of lameness, the degree of muscling index in the severely lame group was significantly greater than the mildly lame group and showed an increase when compared with the index of the never lame group (Table 32).

Comparison of gross lesion values for the two groups of shaken Hampshires with those of the Hampshire controls revealed a non-statistically significant increase in activity in the Hampshires (shaken - 4 days) that was not present in the Hampshires (shaken -11 days) (Table 6). If the increase in total LDH activity four days after shaking results from damage to the articular cartilage, such damage may be repaired by 11 days after shaking.

Synovial fluid of Hampshires (shaken - 4 days) had significantly higher isoenzyme 5 and lower isoenzyme 1 than either Hampshire controls or Hampshires (shaken - 11 days) (Table 9). This observation substantiates the premise that damaged articular cartilage is the origin of increased LDH activity since 70% of the LDH activity in this tissue is represented by isoenzymes 4 and 5 (Tushan et al. 1969). However, since a decrease in isoenzyme 1 indicates a shift to anaerobic metabolism, a change in tissue metabolism may also be involved.

Comparisons of synovial fluid mean cell counts in the two groups of shaken Hampshires with Hampshire controls indicated increased counts in the Hampshires (shaken - 4 days) over Hampshire controls, although statistical significance was not achieved. Increased cell counts were not evident in the Hampshires (shaken - 11 days) (Table 24). This observation paralleled the previous observations of total LDH activity

in which there was an increase four days after shaking but the increase was no longer evident 11 days after shaking. The cellular reaction to induced trauma in synovial fluid appears to be detectable at four days but not 11 days after shaking.

Comparisons of serum and synovial fluid total protein levels, protein fraction distribution, and volume of synovial fluid in the two groups of shaken Hampshires with the control Hampshires indicated that induced trauma, as applied in this experiment, had no effect on these parameters.

Comparisons of the microscopic lesion scores of the two groups of shaken Hampshires with Hampshire controls revealed slightly higher values of lesions A and B and a lower value of lesion C in Hampshires (shaken - 4 days). However, Hampshires (shaken - 11 days) showed a larger increase in lesions A and B compared with Hampshire controls, although statistical significance was not attained. In addition, more marked increases in lesions A, B, and C were observed in Hampshires (shaken - 11 days) compared with Hampshires (shaken - 4 days).

An increase in microscopic lesions was observed in pigs necropsied 11 days after shaking compared with pigs necropsied four days after shaking. These observations are in agreement with the conclusion that gross lesions become apparent 11 days after shaking but not four days after shaking.

Total cell counts in synovial fluid were significantly greater in Yorkshire controls than in Hampshire controls. The higher cell counts in the Yorkshire controls may be a factor in their greater resistance to mycoplasmal arthritis.

total synovial fluid LDH activity, serum and synovial fluid protein levels, and volume of synovial fluid.

There were increased levels of LDH isoenzymes 4 and 5 but this increase did not reach statistical significance when compared with Hampshire controls. However, there was a significant reduction in isoenzyme 1 in Yorkshire controls compared with Hampshire controls (Table 9). This tendency toward anaerobic distribution of LDH isoenzymes in Yorkshires may be a genetic difference.

Comparisons of serum protein fraction distribution of Yorkshire controls with Hampshire controls, as well as with the other three groups of Hampshires, revealed a statistically significant lower gamma globulin level in the Yorkshire controls (Table 17). This difference in gamma globulin levels was also considered to be a genetic effect.

Ross et al. (1971) observed an apparent lack of susceptibility to experimentally induced Mycoplasma hyosynoviae arthritis in a certain genetic line of Yorkshire swine. In the present study of arthritis the incidence of spontaneous lameness and levels of serum gamma globulin were both lower in the Yorkshire controls than in the four groups of Hampshires; therefore, it might be speculated that a correlation exists between these two observations. Further work would be required to confirm or refute this conjecture.

Although statistical significance was not achieved, there was a reduction in synovial fluid gamma globulin in the Yorkshire controls compared with the four Hampshire groups. This reduction in synovial

fluid gamma globulin was considered to be a reflection of the lower levels of serum gamma globulin in the Yorkshire controls (Table 19).

Total cell counts in synovial fluid were significantly greater in Yorkshire controls than in Hampshire controls. The higher cell counts in the Yorkshire controls may be a factor in their greater resistance to mycoplasmal arthritis.

The mean degree of muscling index in Yorkshire controls was significantly lower than in the spontaneously lame group of Hampshires. This observation further substantiates the hypothesis that degree of muscling is related to susceptibility to noninfectious arthritis. In addition, the fact that the incidence of spontaneous lameness was much lower in the Yorkshire controls than in the four groups of Hampshires, further establishes the hypothesis that degree of muscling is related to susceptibility to noninfectious arthritis.

Positive microbiological finding from the mucosae, tonsils, and joints of all 33 pigs utilized in this study were considered as normal contaminants. The fact that seven of the eight joints from which bacteria were cultured were from the normal group substantiates this premise. It was necessary to disarticulate and swab the joints from which no fluid could be aspirated for microbiological culture. Contamination may have occurred during this procedure.

In order to further establish that the swine were free from mycoplasma infection, the sera of all swine utilized in this study were tested by the complement-fixation method and found negative to antibodies for Mycoplasma hyosynoviae and Mycoplasma hyorhinis[1].

[1]Complement-fixation tests performed by Barbara Zimmermann, MT (ASCP), B.S., Iowa State University, Ames, Iowa.

SUMMARY

Morphological and selected clinical chemistry evaluations were made for eight joints from each of 33 swine assigned to five treatment groups. These groups were as follows: Six normal Hampshire controls, six Hampshires necropsied four days after being stressed on a platform shaker, six Hampshires necropsied 11 days after being shaken, seven Hampshires that developed lameness spontaneously, and eight Yorkshire controls.

Comparison of spontaneously lame Hampshires with Hampshire controls revealed the following statistically significant changes: Spontaneously lame Hampshires had higher synovial fluid lactate dehydrogenase (LDH) activity, elevated serum total protein, higher synovial fluid total cell counts, increased volume of synovial fluid, higher synovial membrane microscopic lesion scores, and higher muscling index scores. In addition, gross lesion scores were higher in spontaneously lame Hampshires, but the increase was not statistically significant.

A comparison of pigs necropsied four days after shaking with Hampshire controls disclosed the following statistically significant changes: Synovial fluid from the shaken pigs had higher levels of LDH isoenzyme 5 and lower levels of LDH isoenzyme 1. In addition, the shaken pigs had an increase in synovial fluid total LDH activity and higher synovial fluid cell counts; however, these two changes did not achieve statistical significance.

No significant alterations were observed in pigs necropsied 11 days after shaking compared with Hampshire controls. However, there was an increase in microscopic lesion scores compared with pigs shaken four days prior to necropsy, but this difference was not statistically significant.

Comparison of Yorkshire controls with Hampshire controls revealed the following statistically significant changes: Yorkshire controls had lower levels of LDH isoenzyme 1, lower serum gamma globulin, and higher synovial fluid total cell counts. Muscling index scores in Yorkshire controls were lower than in Hampshire controls but statistical significance was not achieved; however, muscling index scores of Yorkshire controls were significantly lower than the scores of spontaneously lame Hampshires.

A second series of comparisons were made feasible by regrouping the 33 experimental swine by history of lameness. The four classifications used were: 1) never lame, 2) mildly lame, 3) moderately lame, and 4) severely lame groups. The following statistically significant observations were made: Synovial fluid in the severely lame group had higher total LDH activity, higher gamma globulin levels, higher total cell counts, and more volume than either the never lame or mildly lame groups. The severely lame group also had higher scores of the microscopic lesions of vascular proliferation and fibrosis than the never lame and mildly lame groups. Muscling index scores were higher in the severely lame group compared with the mildly lame group. Serum gamma globulin levels were higher in the severely and moderately lame groups, but

this difference was not statistically significant.

A third series of comparisons were made between arthritic joints and normal joints from all study groups. The arthritic joints were selected by gross evaluation. Statistically significant changes based on these joint comparisons were: The synovial fluid from arthritic joints had higher total protein content, higher total cell counts, and increased volume. Other noteworthy changes in arthritic joints were elevation of synovial fluid total LDH activity and increased microscopic lesion scores, although these two changes were not statistically significant.

Synovial fluids from all the experimental swine were negative for mycoplasmas and bacteria. In addition, all swine were serologically negative for antibodies to Mycoplasma hyosynoviae and Mycoplasma hyorhinis.

The following pathogenesis for the nonseptic arthritis observed in this study is proposed: Frequently repeated mild trauma of the articulation results in a tissue reaction characterized by periarticular swelling, increased synovial fluid, hyperemia of the synovial membranes, metabolic changes, a shift in protein fraction distribution, and changes in synovial fluid cell content. Concurrently with these changes, the gross changes of hyperemia, villous hypertrophy, and yellowish or brownish discoloration of the synovial membranes appear. Microscopic changes seen in the synovial membrane include hyperplasia of the lining cells, villous hypertrophy, vascular proliferation, foci of lymphocytes and plasma cells, and fibrosis.

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ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to the following people for the excellent teaching, advice, and encouragement during the course of this study.

To Dr. Richard F. Ross for his interest, encouragement, guidance and assistance with the investigation, and his cooperation in the preparation of this manuscript which contributed greatly to increasing its quality; to Dr. Frank K. Ramsey for valuable advice and encouragement throughout the graduate program and for assistance in preparing the manuscript; and to Dr. John P. Kluge and Dr. Richard C. Ewan for their friendly counsel and assistance and participation on the graduate advisory committee.

The untiring cooperation and highly efficient assistance of Dr. David F. Cox in the statistical evaluation of data is gratefully acknowledged.

The author also wishes to acknowledge the following individuals: Dr. Pat Gough for her efficient assistance with the clinical biochemical procedures; Dr. Robert D. Glock and Dr. Russell L. Kemp for their excellent help with the photography; Mrs. Ione Vold and Mrs. Grace Faber for their excellent work in the preparation of histologic slides; Ann Orning for her efficient assistance with microbiologic procedures; Barbara Zimmermann, Diane Zimmermann, and Elizabeth Yoder for their valuable technical assistance; and Mrs. Cindy Dunlap for her patience and cooperation in the typing of the thesis.

The assistance of Drs. David G. Topel and Lauren L. Christian of the Animal Science Department in the carcass data evaluations was greatly appreciated.

The cooperation and friendly counsel of Art Mann and Hilbert Hoof of the Agricultural Engineering Department in the design and construction of the pig shaking device were greatly appreciated.

The help and encouragement of the staff members of the Department of Pathology and the Veterinary Medical Research Institute are greatly appreciated.

This work was supported by U.S. Public Health Service research grant AI-07921. The support was greatly appreciated and without it this project would not have been possible.

A very special thanks to my wife, Earline, for her patience, understanding, encouragement and untiring assistance.